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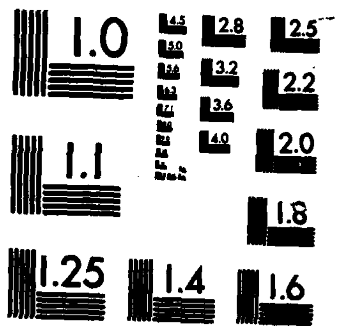

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TECHNICAL REPORT HL-84-12

US Army Corps of Engineers

NAVIGATION CONDITIONS AT MITCHELL LOCK AND DAM COOSA RIVER, ALABAMA

Hydraulic Model Investigation

by

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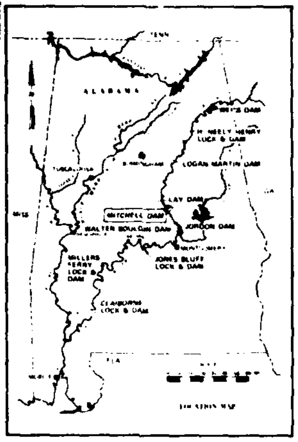

December 1984
Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Mitchell Lock is the second navigation structure proposed for the development of navigation in the Coosa River waterway. The 84- by 600-ft lock will be located at Mitchell Dam and powerhouse about 37.3 miles upstream of the mouth of the Coosa River near Verbena, Alabama.

A fixed-bed model reproducing about 4 miles of the Coosa River and adjacent overbank areas to an undistorted scale of 1:120 was used to provide

(Continued)

20. **ABSTRACT (Continued).**

>some general information on navigation conditions with the proposed designs and to develop such modifications as might be required to eliminate conditions that would adversely affect navigation. Results of the investigation revealed:

a. With medium to high flows, navigation conditions at the Highway 22 Bridge were hazardous for both upbound and downbound tows due to the high velocities and limited width provided through the navigation span with the existing piers and low superstructure. Navigation conditions were acceptable at the bridge for low flows.

b. With the first lock alignment (Plans A and A-1), navigation conditions were acceptable with the 35,000-cfs flow only. With flows greater than 35,000 cfs, navigation conditions were hazardous in the upper pool due to the upstream guard wall perpendicularly intersecting the currents.

c. With the second lock alignment (Plans B, B-1, B-2, and B-3), navigation conditions were acceptable for the 35,000-cfs flow. With flows higher than 35,000 cfs, navigation conditions were hazardous in the lower pool due to the current alignment, high velocities, and the short maneuvering distance between the lock approach and the Highway 22 Bridge.

d. With the third lock alignment (Plans C and C-1), navigation conditions were acceptable for all flows evenly distributed through the gated dam up to and including the 90,000-cfs flow. With the modifications in Plan C-1, the navigation conditions were improved in the lower lock approach with the low flows and the 65,000-cfs unevenly distributed flow. Navigation conditions were hazardous with flows greater than 90,000 cfs due to the current alignment, high velocities, and the limited clearance at the Highway 22 Bridge.

e. Flows unevenly distributed through the gated dam could cause navigation problems in the lower pool.

f. Navigation conditions would be hazardous for tows in the upper lock approach canal during lock filling.

g. Navigation conditions would be hazardous for tows at the end of the lower guard wall when emptying the lock into the lower approach with no riverflow. The problem was eliminated by a riverflow of 35,000 cfs or by emptying the lock into the river.

PREFACE

The model investigation reported herein was authorized by Office, Chief of Engineers, US Army, in 2nd Indorsement, dated 23 April 1979, to the Division Engineer, US Army Engineer Division, South Atlantic (SAD). The study was conducted for the US Army Engineer District, Mobile (SAM), in the Hydraulics Laboratory of the US Army Engineer Waterways Experiment Station (WES) during the period June 1979 to May 1983.

The investigation was conducted under the general supervision of Messrs. H. B. Simmons, Chief of Hydraulics Laboratory, and F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory, and under direct supervision of J. E. Glover, Chief of the Waterways Division. The engineer in immediate charge of the model was Mr. L. J. Shows, Chief of the Navigation Branch, assisted by Messrs. R. T. Wooley, T. K. Kyzar, and Mrs. C. M. Myrick. This report was prepared by Mrs. Myrick.

During the course of the model study, representatives from SAM, SAD, US Geological Survey, Alabama Power Company, and Southern Company Services visited WES at different times to observe special model tests and discuss results. SAM was informed of the progress of the study through monthly progress reports and special reports at the end of each test.

Commanders and Directors of WES during the course of the investigation and the preparation and publication of this report were COL Nelson P. Conover, CE, COL Tilford C. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, US CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

US customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
miles (US statute)	1.609344	kilometres
square miles (US statute)	2.589988	square kilometres

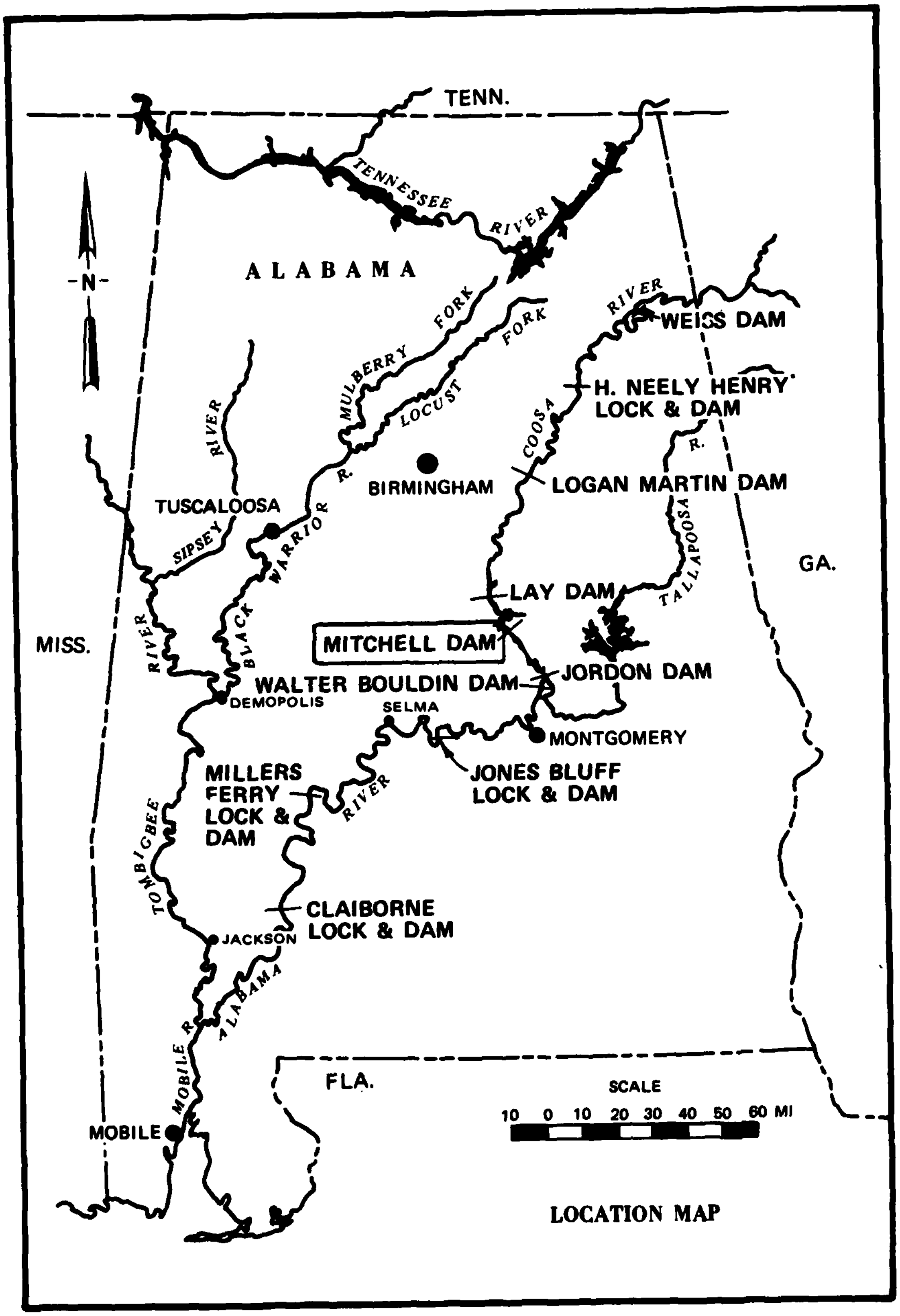

Figure 1. Vicinity map

NAVIGATION CONDITIONS AT MITCHELL LOCK AND DAM

COOSA RIVER PROJECT

Hydraulic Model Investigation

PART I: INTRODUCTION

Description of Prototype

1. The Coosa River is formed by the confluence of the Oostanaula and Etowah Rivers near Rome, Georgia, and flows southwesterly about 286 miles* to Wetumpka, Alabama, where it joins with the Tallapoosa River to form the Alabama River (Figure 1). The river drains an area of about 10,200 square miles. Presently, six dams are located on the river with an additional dam on a dredged canal. Mitchell Lock and Dam is located on the Coosa River at river mile 37.3 near Verbena, Alabama. The reservoir with normal upper pool el 312.0** extends approximately 14 miles upstream to the Lay Dam.

2. The existing Mitchell development consists of a concrete dam with a 780-ft-long gated spillway section, a fixed-crest spillway section and an overflow section, and a four-unit powerhouse situated in the middle of the river just upstream of the gated spillway section. Mitchell Dam is currently undergoing redevelopment which consists of a new three-unit powerhouse on the right bank and three new spillway gates on the left bank. After redevelopment, with one existing unit remaining in service, the total discharge capacity of the power plant will be approximately 35,000 cfs.

History of Project

3. The River and Harbor Act of 1945 authorized development of the Alabama-Coosa River system for navigation, flood control, and power development. In June 1954, Public Law 436 suspended authorization for Federal hydropower development on the Coosa River to permit the Alabama Power Company to

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* A table of factors for converting US customary units of measurements to metric (SI) units is presented on page 3.

** All elevations (el) cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

develop the river from the vicinity of Montgomery, Alabama, to Rome, Georgia, by construction of a series of hydropower dams. An interim report printed in House Document 320 in January 1960 recommended that the navigation project for the Coosa River from Montgomery to Gadsden, Alabama, be accomplished after the waterway to Montgomery was assured. It recommended that the project for the reach between Gadsden and Rome be accomplished when the waterway to Gadsden was assured and economic justification of the extension established.

4. The Alabama River Project providing navigation to Montgomery was completed in January 1972.

5. The Alabama Power Company has constructed seven Coosa River hydropower dams. The dams were planned, constructed, and rights-of-way reserved to permit future development of navigation on the Coosa River through the addition of locks.

Present Development Plan

6. The principal features of the authorized Coosa River navigation project to Gadsden provide for installing navigation locks at the existing Alabama Power Company's Walter Bouldin, Mitchell, Lay, Logan Martin, and H. Neely Henry Dams and constructing a 9- by 150-ft navigation channel.

7. Mitchell Lock is proposed for construction in the left overbank area of the dam. The lock will have clear chamber dimensions of 84 by 600 ft, a maximum lift of 70 ft, and the necessary entrance and exit channels.

Need and Purpose of Model Study

8. The general design of Mitchell Lock was based on sound theoretical design practice and experience with similar structures. However, conditions through the reach approaching and leaving the lock could be expected to be extremely complex because of the effects of currents approaching and leaving the dam, irregular channel alignment and configuration, limited channel width, high velocities, crosscurrents, and surges created by lock filling and emptying. Also, navigation conditions vary with location and flow conditions upstream and downstream of a structure; and an analytical study to determine hydraulic effects expected to result from a particular design is both difficult and inconclusive. Therefore a comprehensive model study was considered necessary:

a. To determine the best alignment of the lock, the arrangement of the lock and lock walls, the lock approach entrance and exit configurations, and navigation conditions that would result from the proposed plan and various riverflows.

b. To determine modifications that could be used to eliminate or minimize any undesirable conditions indicated.

c. To determine the effects of lock filling and emptying and powerhouse releases.

d. To demonstrate to design engineers and power and navigation interests the conditions that would result from various plans and modifications.

PART II: THE MODEL

Description

9. The model (Figure 2) reproduced about 4 miles of the Coosa River channel, Mitchell Lake, and the adjacent overbank areas from about 14,500 ft above and 6,500 ft below Mitchell Dam. The model was of the fixed-bed type with the channel and overbank areas molded in sand-cement mortar to sheet-metal templates. Portions of the model, where changes in lock alignments and channel configurations were considered or could be anticipated, were molded in pea gravel to allow for easy modification. The lock, dam crest, piers, powerhouse, and guard walls were built from sheet metal. The dam gates were simulated schematically with simple sheet-metal slide-type gates. The powerhouse units were connected to a pumping system and flowmeters which could be operated to reproduce variations in powerhouse releases.

10. The channel portion of the model was molded to conform to a hydrographic survey dated March 1979 and the overbank areas were molded to a topographic survey dated December 1978. Overbank areas were reproduced to a maximum elevation of 340.0, which was sufficient to permit the investigation of flows that would affect navigation.

Scale Relations

11. The model was built to an undistorted linear scale ratio of 1:120, model to prototype, to obtain accurate reproduction of velocities, crosscurrents, and eddies that would affect navigation. Other scale ratios resulting from the linear scale ratio were as follows:

Area	1:14,400
Velocity	1:10.95
Time	1:10.95
Discharge	1:157,743
Roughness (Manning's n)	1:2.22

Measurements of discharges, water-surface elevations, and current velocities can be transferred quantitatively from model-to-prototype equivalents by means of these scale relations.

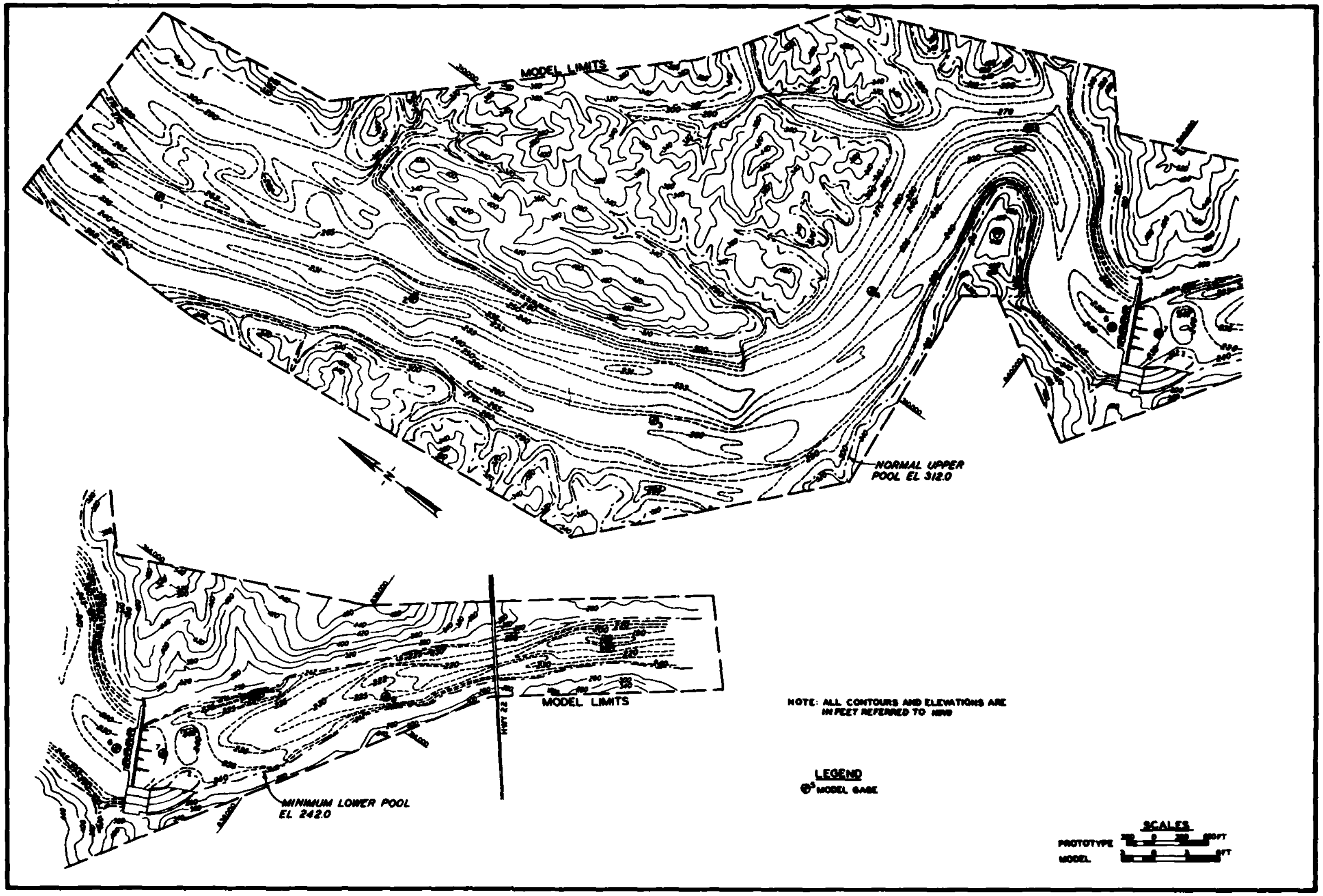

Figure 2. Base conditions

Appurtenances

12. Water was supplied to the model by means of a 5-cfs pump operating in a circulating system. The discharge was controlled and measured at the upper end of the model by means of a valve and venturi meter. Water-surface elevations were measured by means of piezometer gages located in the model channel and connected to a centrally located gage pit. A tailgate was provided at the lower end of the model to control the tailwater elevations downstream of the dam and slide-type gates in the spillway were used to maintain the upper pool elevation. Surges were measured with continuous recording gages and velocity meters placed at selected ranges. Powerhouse discharges were controlled by means of a pumping system connected to a programmer and control panel.

13. Velocities and current directions in the model were determined by means of wooden cylindrical floats weighted on one end to simulate the maximum permissible draft for loaded barges using the waterway (9 ft prototype). A model towboat and tow were used to determine and demonstrate the effects of currents on tows approaching and leaving the lock. The towboat was equipped with twin screws and was propelled by a small electric motor operating from a battery in the tow. The rudders and speed of the tow were remote-controlled, and the tow could be operated in forward or reverse at a speed comparable to that of towboats expected to use the Coosa River waterway.

Model Adjustment

14. The model surface was constructed of brushed cement mortar to provide a roughness (Manning's n) of about 0.0135 which corresponds to a prototype roughness of about 0.030. With the existing dam and powerhouse in place, the model was checked against limited prototype data which consisted mostly of current directions and velocities with low flow conditions. Results indicated that the model reproduced the existing prototype conditions with a reasonable degree of accuracy.

PART III: TESTS AND RESULTS

Test Procedures

15. Tests were concerned primarily with the study of flow patterns, measurement of velocities, surges, water-surface elevations, and effects of currents on the movement of the model tows approaching and leaving the lock with various riverflows.

16. The following representative flows were used for testing based on information furnished by the US Army Engineer District, Mobile. All flows were tested with the normal upper pool el 312.0.

a. Controlled riverflow of 5,000 cfs with tailwater el 250.9.

b. Controlled riverflow of 15,000 cfs with tailwater el 251.0.

c. Controlled riverflow of 35,000 cfs with tailwater el 251.6.

d. Controlled riverflow of 65,000 cfs with tailwater el 252.7.

e. Controlled riverflow of 90,000 cfs with tailwater el 255.3.

f. Controlled riverflow of 130,000 cfs with tailwater el 257.4.

g. Maximum navigable, controlled riverflow of 175,000 cfs with tailwater el 260.0.

17. The controlled riverflow was reproduced by introducing the proper discharge, setting the tailwater elevation for the discharge, and manipulating the dam gate openings and/or powerhouse units until the required upper pool elevation was obtained. All stages were permitted to stabilize before data were recorded except during lock filling and emptying and changes in powerhouse releases. Start of powerhouse units was assumed to be instantaneous.

18. Velocities were determined by timing the travel of floats over measured distances. Current directions were determined by plotting the paths of floats with respect to ranges established for that purpose. In plots of currents in turbulent areas or where eddies or crosscurrents existed, only the main trends are shown in the interest of clarity. No data were obtained with the model tow, except to observe and record on multiple exposure photographs the behavior of the tow as affected by currents in the lock approaches and through the reach. Continuous recording gages and velocity meters were used to measure water surface and velocity surges during lock filling and emptying and start of powerhouse releases.

Base Tests

Description

19. Base tests were conducted with the redeveloped Mitchell powerhouse in operation. The purpose of these tests was to provide information and data that could be used in determining the effects of the proposed modifications on water-surface elevations and current directions and velocities before the lock was installed on the model. The principal features shown in Figures 2 and 3 include:

- a. A nonnavigable gated spillway with 23 tainter gates 30 ft wide by 15 ft high with the crest el 297.0.
- b. Two fixed crests bays 30 ft wide with crest el 312.0 and an overflow section 88 ft wide with crest el 322.0.
- c. The redeveloped power plant with the new three-unit powerhouse on the right bank and one existing unit in operation.
- d. The Alabama Highway No. 22 Bridge.

Results

20. Water-surface elevations shown in Table 1 indicate that slopes in the upper pool are less than 0.3 ft/mile for all flow conditions. In the lower pool, slopes ranged from 0.3 ft/mile for the 35,000-cfs flow to 1.8 ft/mile for the 175,000-cfs flow.

21. Current directions and velocities shown in Plates 1-4 indicate that velocities in the upper pool were generally slow and uniform across the channel until approaching the point immediately upstream of the dam. There the maximum velocities on the right side of the channel ranged from 0.7 for the low flow to about 7.0 fps for the highest flow. Velocities in the left half of the channel were much lower, less than 2.5 fps at the highest flow. A large eddy developed along the right bank downstream of the point. In the lower pool, currents approached the bridge at an angle of approximately 15 deg with maximum velocities in the vicinity of the bridge ranging from 3.7 fps at the 30,000-cfs flow to 14.0 fps at the 175,000-cfs flow. At low flows, a large eddy formed downstream of the powerhouse.

Plan A

Description

22. Plan A involved the construction of a navigation lock at Mitchell

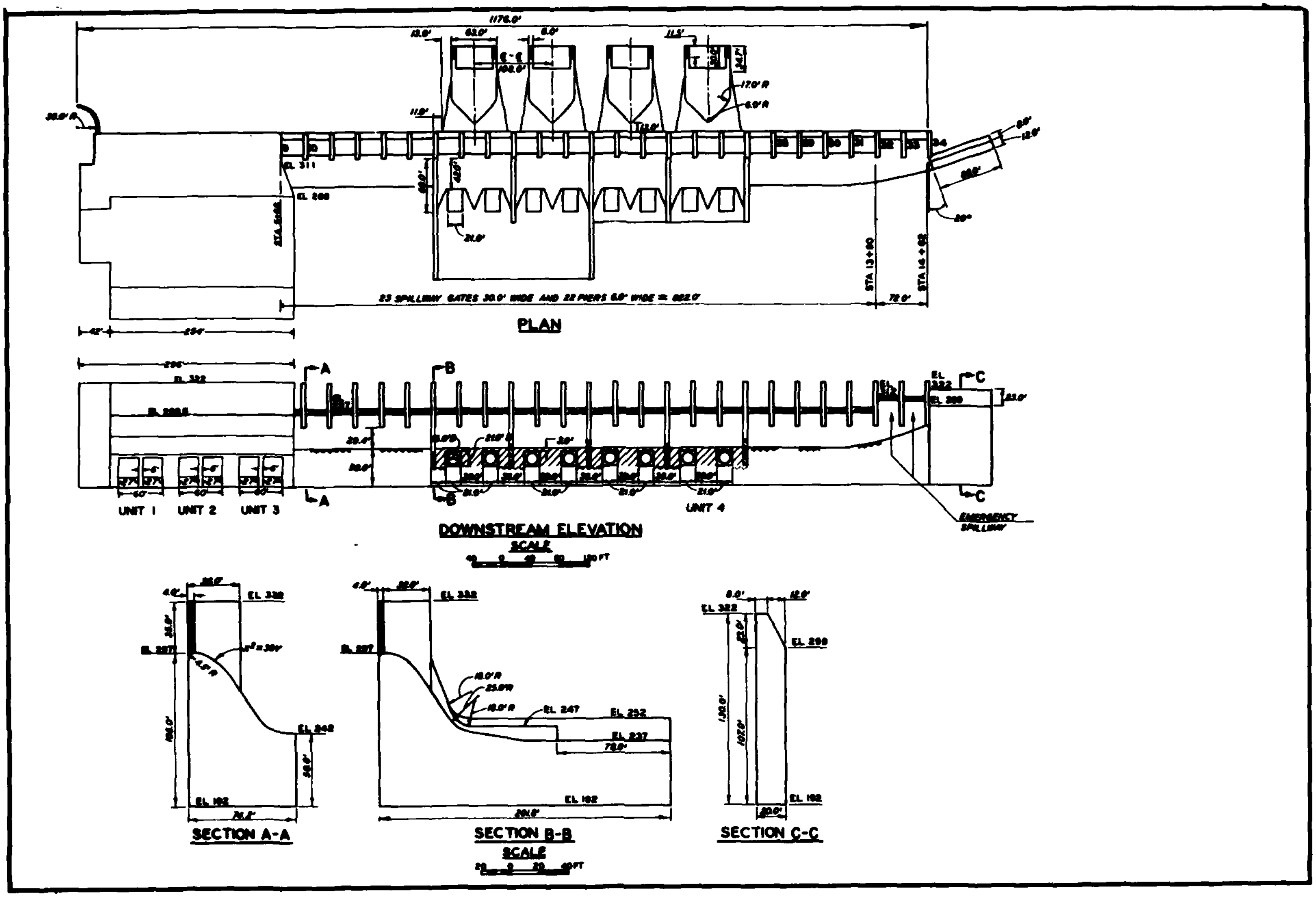

Figure 3. Base conditions, powerhouse and spillway

Dam on the first proposed alignment adjacent to the dam. The additional principal features include (Figures 4 and 5):

a. A navigation lock with clear chamber dimensions of 84 by 600 ft along the left bank adjacent to the overflow section, a 600-ft-long ported upper guard wall, and a 514-ft-long lower guard wall with top el 269.0.

b. The downstream lock approach excavated to el 227.0.

Results

23. Water-surface elevations shown in Table 2 indicate no significant changes compared with base conditions.

24. Current directions and velocities shown in Plates 5-7 indicate little change from base conditions in the current alignment except for an eddy forming in the upper lock approach. The upper guard wall extended into the pool normal to currents with approach velocities ranging from 0.3 to 4.9 fps for the various flows. In the lower pool, velocities at the end of the guard wall ranged from about 3.6 to 6.5 fps with the maximum velocities in the vicinity of the bridge ranging from 3.8 to 12.7 fps.

25. Navigation conditions in the upper lock approach would be difficult at low flows and hazardous at high flows. With all flows, downbound tows would approach the upstream guard wall at a steep angle due to the alignment of the guard wall with respect to the river channel and would experience difficulty aligning with and laying against the guard wall. With flows of 90,000 cfs and above, downbound tows were in danger of being slammed against the guard wall with considerable force by the high-velocity currents approaching the wall. Upbound tows would have difficulty breaking free of the guard wall and would have to rotate the head of the tow about 45 to 60 deg before they could maneuver off the wall. Upbound tows with the ability to maneuver off the upstream guard wall could navigate through the reach with no additional problems.

26. In the lower pool, tows would have no problems entering or leaving the lock approach. However, upbound tows would have to overcome extremely high-velocity currents in the approach to the lock at medium to high flows. Upbound tows with sufficient power to maintain headway and steerage could approach the lock without any major problems. However, navigation conditions at the Highway 22 Bridge could be hazardous at medium to high flows due to the limited clearance provided at the bridge with the existing piers and low superstructure and the high-velocity currents for both upbound and downbound tows.

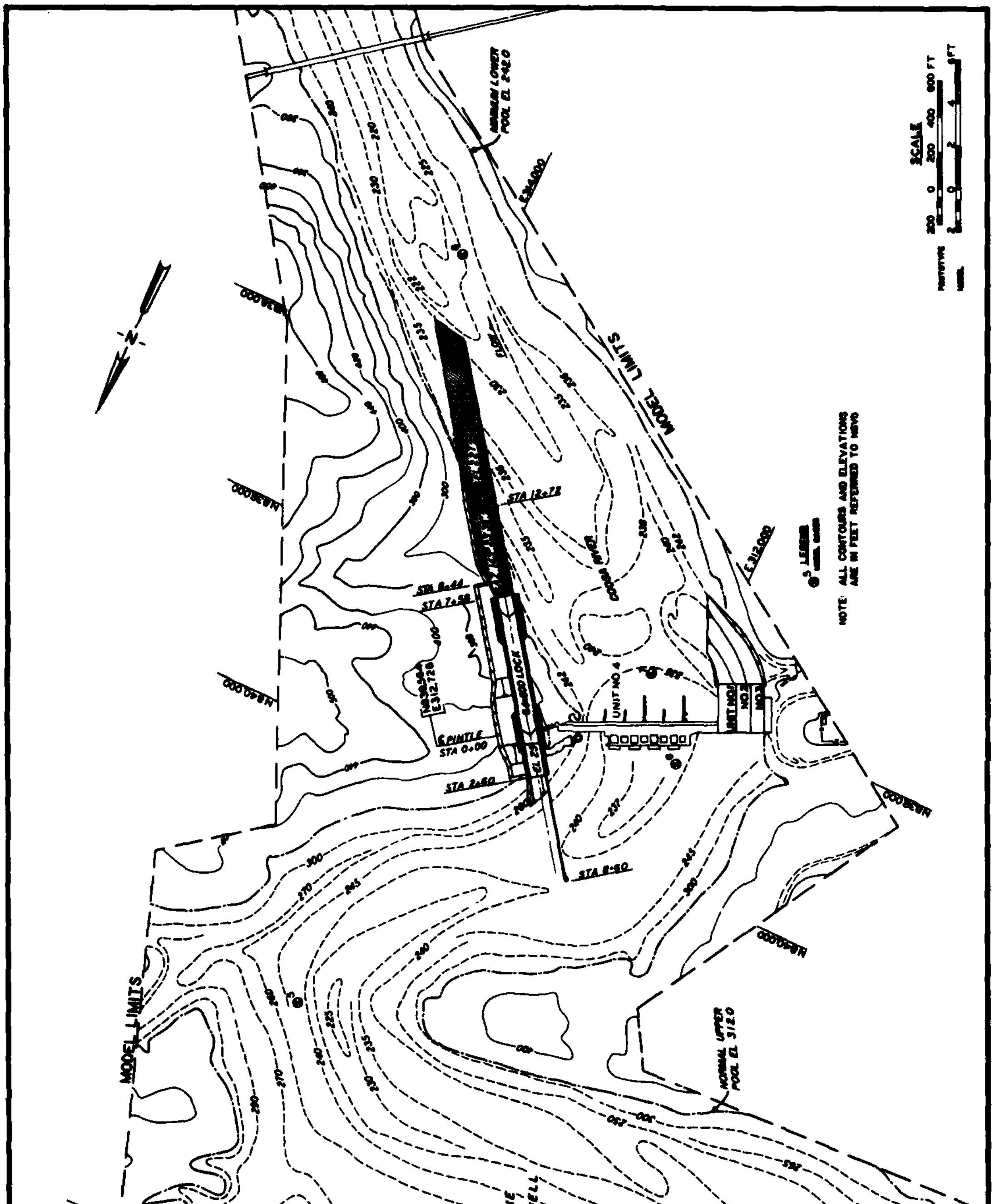

Figure 4. Plan A

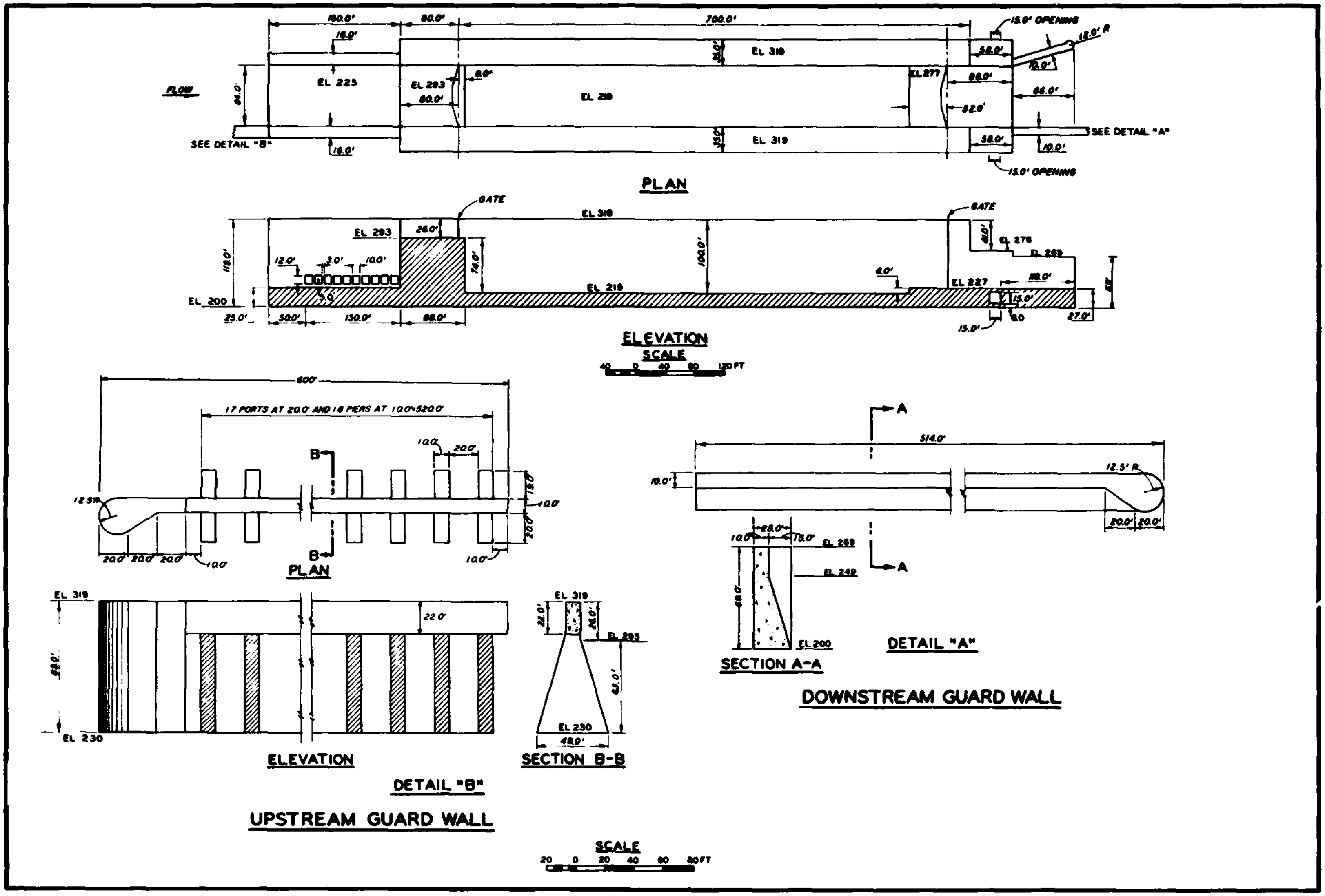

Figure 5. General plan of lock

Plan A-1

Description

27. Plan A-1 was the same as Plan A except that in the upper pool (Figure 6) a 150-ft-wide canal with bottom el 285.0 was excavated through the point on the right overbank upstream of the lock as proposed by the District. There were no changes downstream of the dam.

Results

28. Water-surface elevations shown in Table 3 were unchanged from Plan A.

29. Current directions and velocities shown in Plate 8 indicate maximum velocities through the canal ranging from 0.7 to 5.7 fps. Alignment and velocities of currents approaching the upper guard wall were not significantly changed compared with Plan A. Currents adverse to navigation would tend to develop between the end of the upper guard wall and the canal entrance with maximum velocities ranging from 0.4 to 4.5 fps.

30. At the 35,000-cfs flow, a tow could enter and leave the upper lock approach through the canal with no problems. However, with the 90,000- and 175,000-cfs flows, a downbound tow entering the canal would tend to be grounded along the left bank line of the canal. A downbound tow navigating between the canal and the lock would encounter strong crosscurrents and would tend to be moved downstream of the lock approach. Navigation conditions with this plan could be hazardous particularly with the high flows. Tows could be moved from the lock approach and onto the gated dam or downbound tows could strike the upper end of the guard wall and break loose from the tow. An upbound tow encountering the crosscurrents as it cleared the end of the guard wall would be pushed downstream causing it to be pushed aground on the right bank of the canal.

Plan B

Description

31. Plan B involved locating the navigation lock on the second proposed alignment in a canal in the left overbank area and redeveloping the Mitchell spillway. Modifications (Figures 7 and 8) included:

a. The lock located in a 150-ft-wide canal with bottom el 293.0, a 400-ft upper guide wall, and a 514-ft lower guide wall.

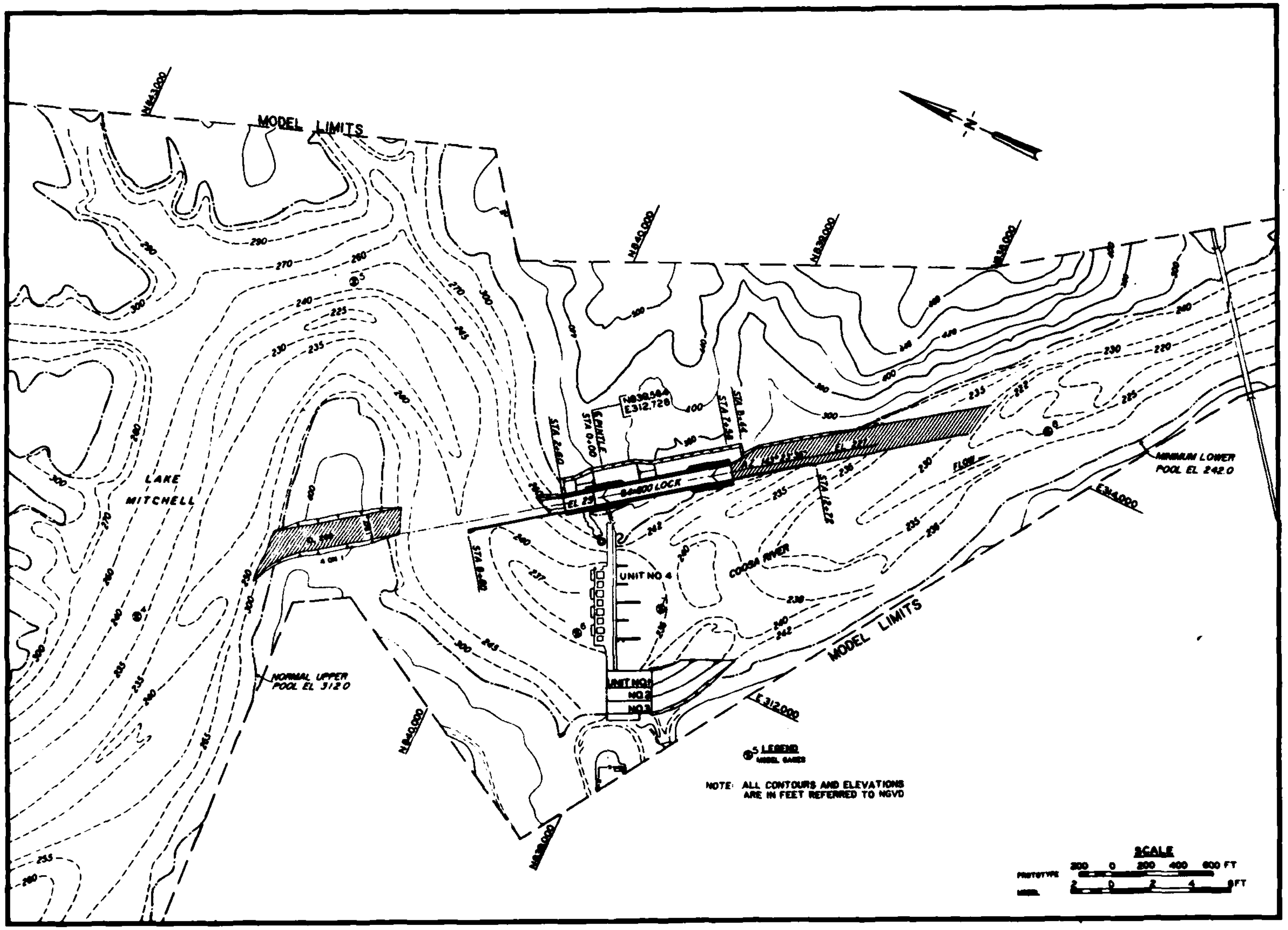

Figure 6. Plan A-1

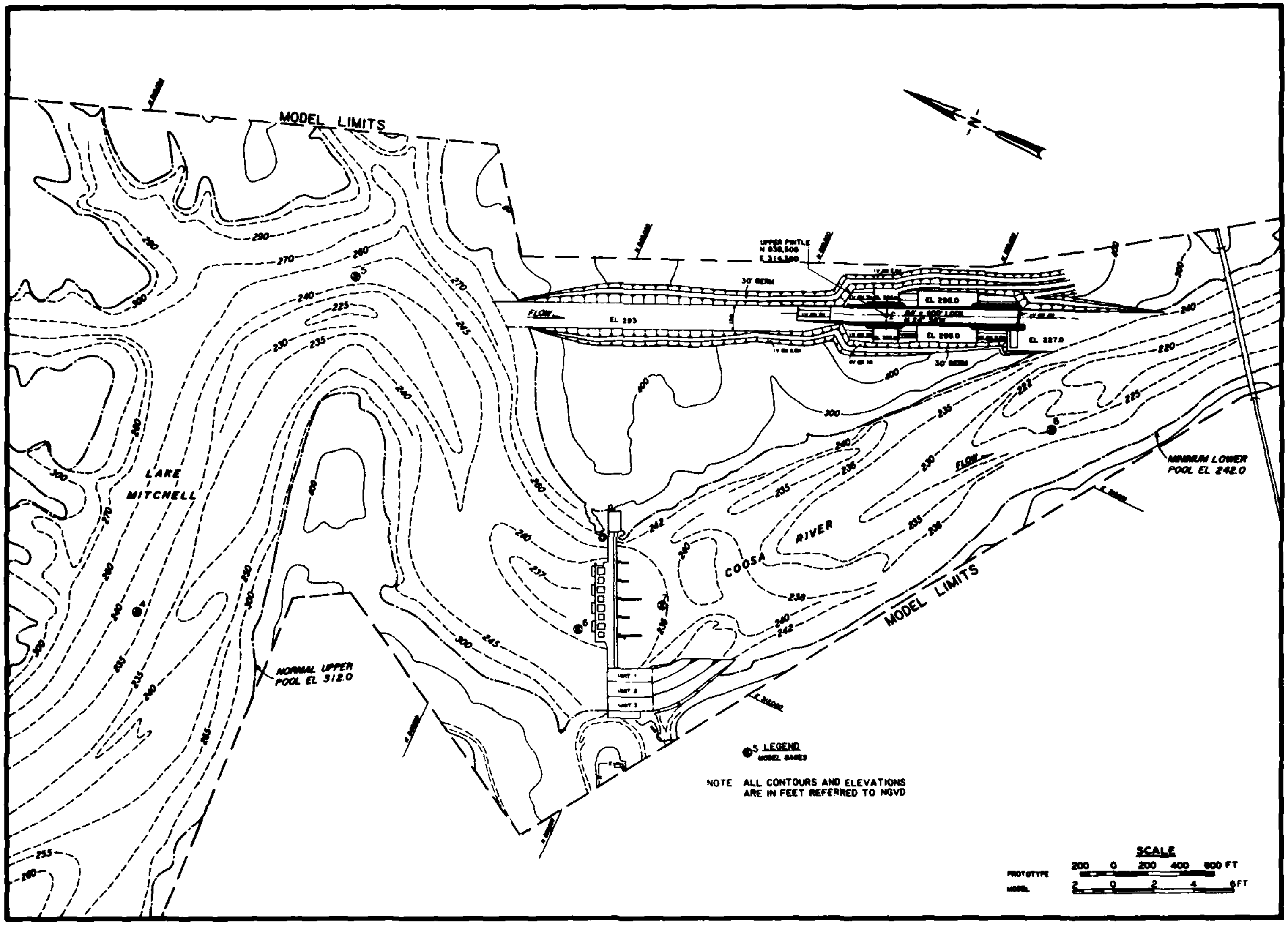

Figure 7. Plan B

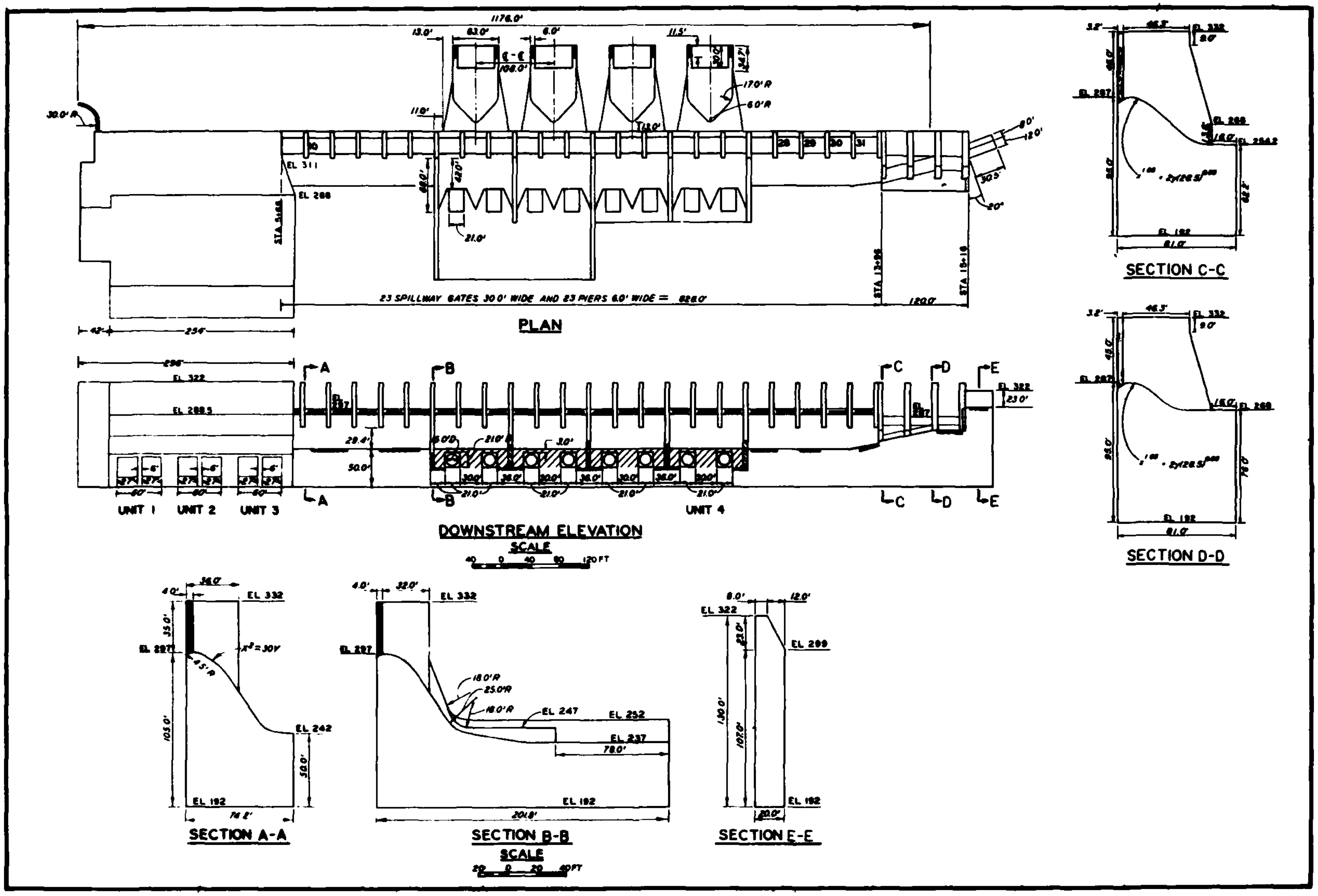

Figure 8. Plan B powerhouse and spillway

b. Three 30-ft-wide spillway bays with crest replacing two fixed-crest bays and 57.5 ft of the overflow section.

Results

32. Water-surface elevations shown in Table 4 indicate no significant changes compared with base conditions.

33. Current directions and velocities shown in Plates 9-12 indicate that currents at the entrance to the upper lock canal had maximum velocities ranging from less than 0.5 to about 2.4 fps. In the lower pool, the velocities of the crosscurrents where the lock approach entered the main river channel ranged from about 1.1 fps for the lowest flow to about 5.2 fps at the highest flow and increased to 2.8 to 12.5 fps, respectively, within about 500 ft downstream. A slow eddy would tend to develop in the lower lock approach.

34. In the upper pool, a downbound tow approaching the lock canal from near midchannel to the left bank of the bend could enter the lock canal with no significant problems at low flows. However, due to the narrow width of the canal entrance, coupled with the adverse current alignment, it could be extremely difficult for a downbound tow to become properly aligned with and enter the lock canal at medium flows. At high flows, navigation conditions were hazardous for upbound and downbound tows at the entrance of the lock canal where the currents could push the tow aground on the point of the canal embankment or sweep it downstream into the dam. Upbound tows at low to medium flows encountered no significant problems leaving the lock canal.

35. In the lower pool at low flows, a tow could enter and leave the lock approach and navigate through the bridge with no problems. At the 65,000-cfs and higher flows, navigation conditions were hazardous. A downbound tow leaving the lower lock approach could be pushed into the left bridge pier of the navigation span due to the current alignment, high velocities, and the short maneuvering distance between the lock canal and the bridge. An upbound tow would encounter extremely high velocities and was in danger of being pushed aground on the left bank as it entered the lower lock approach. An eddy in the lower approach tended to rotate the head of the tow off the guide wall increasing the difficulty in landing on the wall and requiring additional maneuvering.

Plans B-1, B-2, and B-3

Description

36. Plans B-1, B-2, and B-3 involved modifications to develop

satisfactory navigation conditions at the entrance of the upstream lock canal. There were no changes downstream of the dam. The features were the same as Plan B except that:

a. Plan B-1. The entrance to the lock canal was widened to 200 ft and aligned on a 2,600-ft radius curved toward the left bank (Figure 9).

b. Plan B-2. The entrance to the lock canal was flared on a 15-deg angle (Figure 10) to reduce excavation required.

c. Plan B-3. A 420-ft-long dike with top el 314.0 and side slopes of 1V on 1.5H was added just downstream of the entrance to the lock canal (Figure 11) to eliminate navigation problems at high flows.

Results

37. Water-surface elevations shown in Tables 5-7 indicate no significant changes compared with Plan B.

38. Current directions and velocities for Plans B-1 and B-2 (Plates 13 and 14) indicate no significant change from Plan B. The addition of the dike on Plan B-3 created a local effect on current directions and velocities (Plate 15) causing a large slow eddy to develop upstream of the dike at the entrance to the lock canal.

Plan B-1

39. Navigation conditions in the upper pool were good at all flows tested. The entrance of the upper lock canal was located in the slow currents along the left bank. Downbound tows navigating along the left bank could align with and enter the widened canal with no problems. Upbound tows could leave the lock canal with no danger of being pushed downstream.

Plan B-2

40. Plan B-2 reduced the excavation at the entrance of the upper lock canal that would be required for Plan B-1. Navigation conditions for upbound tows leaving the lock canal were good for all flows. Downbound tows approaching the upstream lock canal from near midchannel to the left bank would have no problems entering the canal at low and medium flows. At high flows, navigation conditions were hazardous for downbound tows at the entrance to the canal where the currents could move the tow out of alignment into the right bank of the canal or downstream into the gated dam.

Plan B-3

41. Plan B-3 eliminated the problem the tow experienced in aligning with the canal at high flows and further reduced the excavation required at the

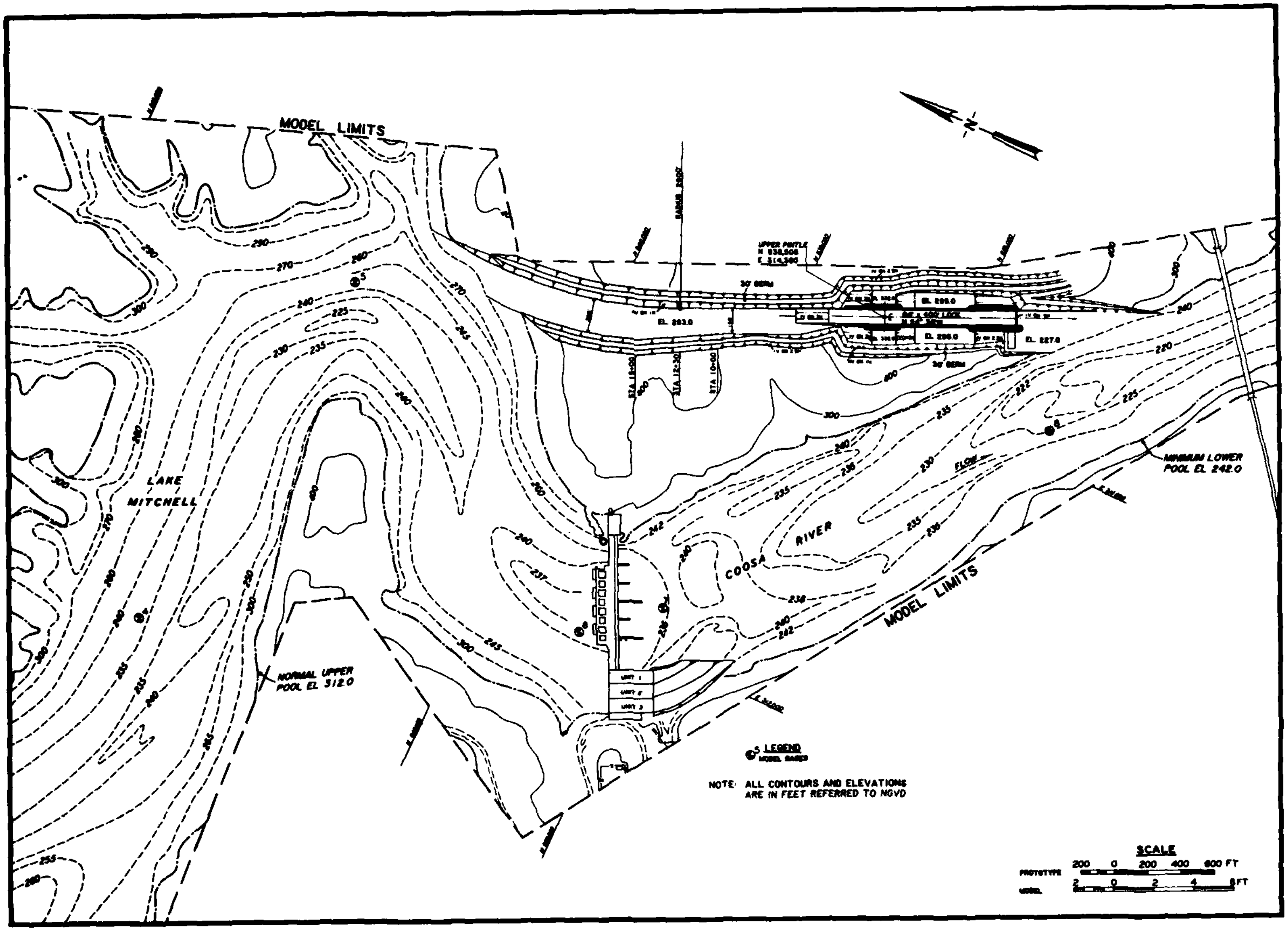

Figure 9. Plan B-1

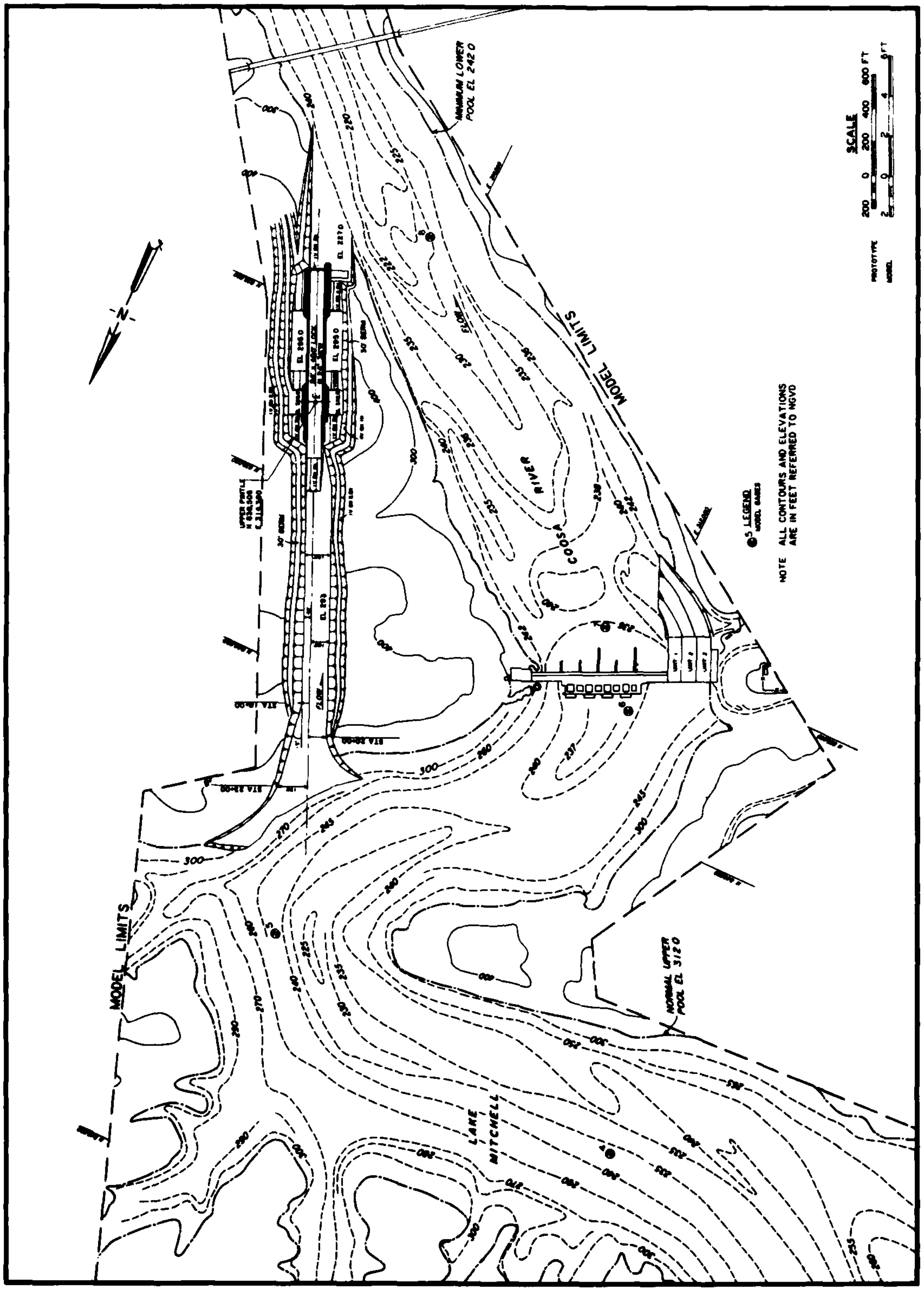

Figure 10. Plan B-2

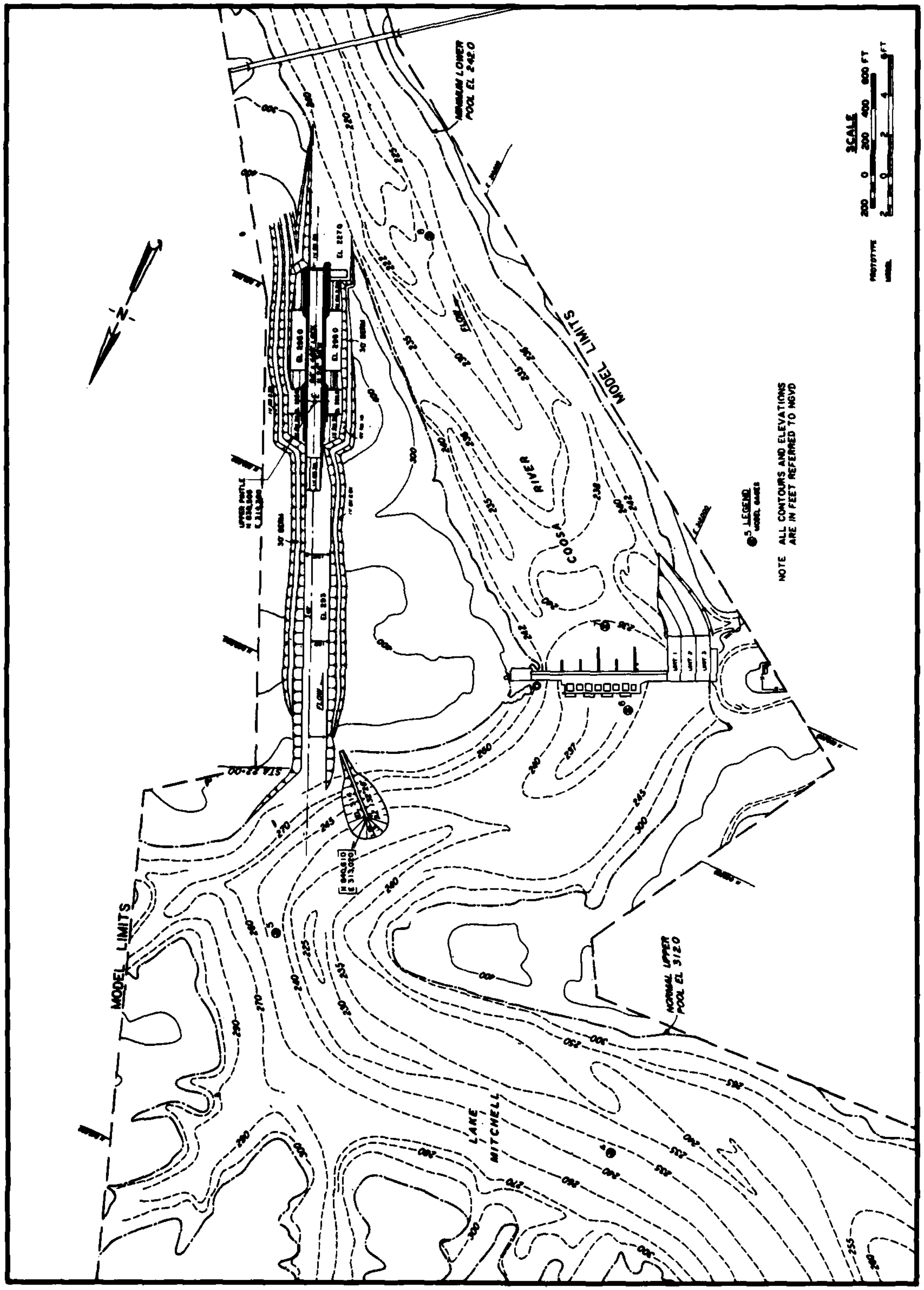

Figure 11. Plan B-3

entrance to the upper lock canal. With all flows, upbound tows encountered no problems leaving the lock canal. Navigation conditions were satisfactory with all flows for downbound tows entering the lock canal from near midchannel to the left bank provided the tow avoids the eddy on the extreme left bank just upstream of the entrance to the lock canal. The eddy presented no danger to the tow but would require considerable maneuvering for the tow caught in the eddy to align with and enter the canal.

Plan C

Description

42. Plan C involved realigning the lock to improve navigation conditions in the lower approach (Figure 12). Features were the same as Plan B except that the lock was rotated in the left overbank and the lower entrance to the lock canal was moved upstream about 1,700 ft providing a longer maneuvering distance between the bridge and the lock canal and reducing excavation in the lower approach. The lower guard wall was moved to the riverside of the lock to prevent the tow from being pinned against the wall by the currents.

Results

43. Water-surface elevations shown in Table 8 indicate that the slope in the lower reach would increase to about 1.0 ft/mile for the 90,000-cfs flow and 2.3 ft/mile for the 175,000-cfs flow.

44. Current directions and velocities shown in Plates 16-21 indicate little change in the upper pool from base conditions. The entrance to the upper lock canal aligned with the slow currents along the left bank. In the lower pool at the 15,000- and 35,000-cfs flows there was turbulence at the end of the guard wall and an eddy developed in the lower approach. For higher flows evenly distributed through the gated dam the turbulence decreased. With the 65,000-cfs flow distributed through the powerhouse and the five adjacent gates only, the currents became turbulent at the end of the guard wall and erratic at the bridge. Maximum velocities at the bridge ranged from 3.3 fps for the 35,000-cfs flow to 14.3 fps for the 175,000-cfs flow.

45. In the upper pool, satisfactory navigation conditions were developed with all flows tested. Upbound tows leaving the lock canal could navigate upstream with no problems. Downbound tows could align with and enter the lock canal from near midchannel to the left bank provided the tow avoids the eddy

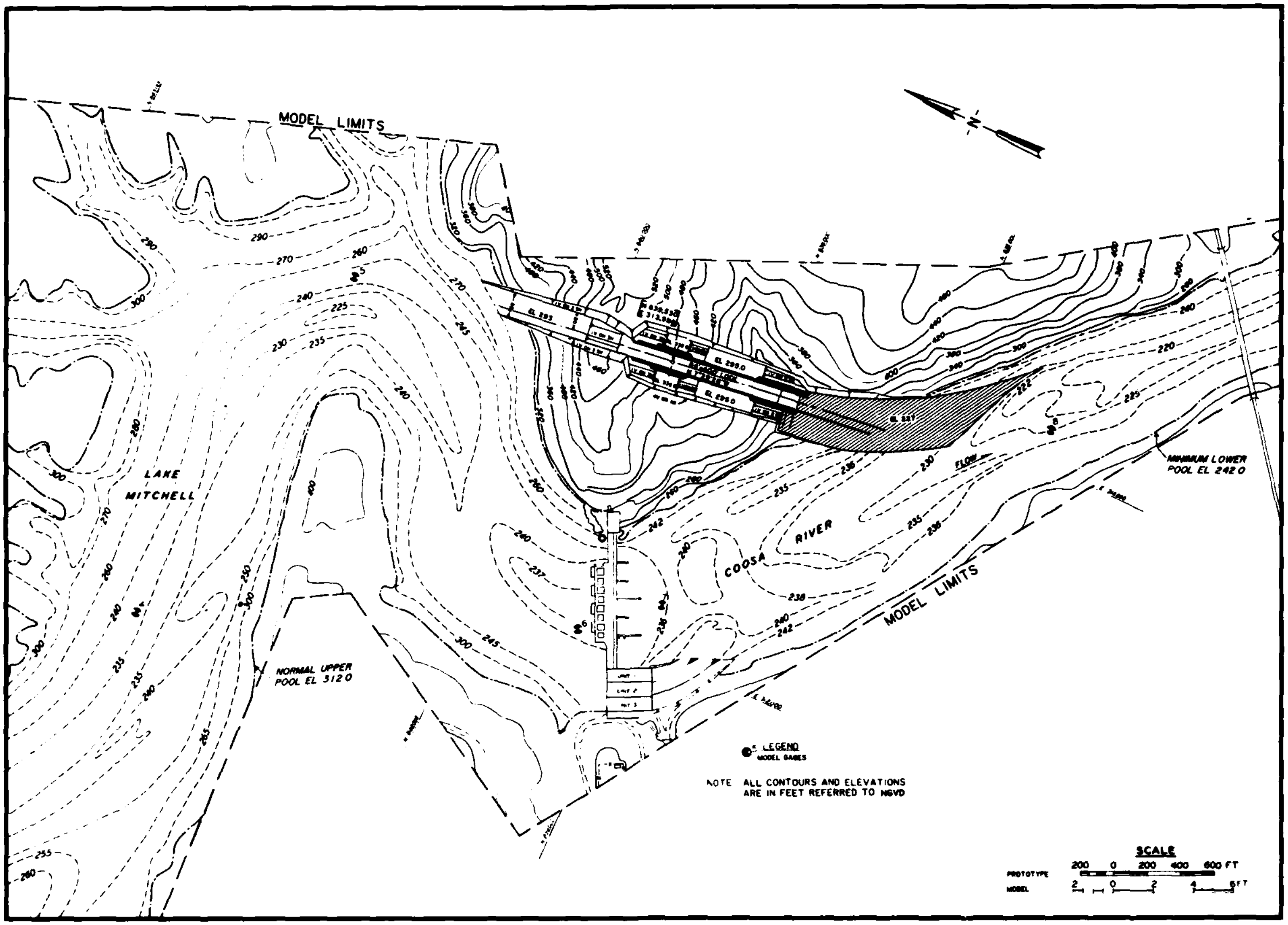

Figure 12. Plan C

on the extreme left bank just upstream of the canal entrance. The eddy presented no danger to the tow but would require maneuvering for the tow to align with and enter the canal.

46. In the lower pool, a downbound tow could leave the lower lock approach and maneuver to align with the bridge for all flows evenly distributed through the gated dam up to and including the 90,000-cfs flow. At the 130,000- and 175,000-cfs flows, navigation conditions were hazardous with a downbound tow in danger of being pushed into the left bridge pier. At low flows, an upbound tow could be pushed aground on the left bank of the lock approach from the turbulence created by the guard wall or caught in the eddy in the lower lock approach, requiring additional maneuvering to land on the wall. With evenly distributed higher flows, an upbound tow could approach the lock satisfactorily. However, conditions at the bridge were hazardous, even for tows with sufficient power to navigate the high-velocity currents at the bridge. For the unevenly distributed 65,000-cfs flow, navigation conditions were hazardous for both upbound and downbound tows.

Plan C-1

Description

47. Plan C-1 was the same as Plan C except that three vane dikes were added upstream of the lower guard wall to straighten the currents and reduce velocities in the lower lock approach and two 20-ft-diam protection cells were placed in the upper pool aligned with the right bank of the lock canal (Figure 13). Dike 1 was 300 ft long with top el 259.0. Dikes 2 and 3 were 230 ft long with top el 252.0.

Results

48. Water-surface elevations shown in Table 9 indicate an increase in the lower pool of about 0.1 ft over Plan C.

49. Current directions and velocities shown in Plates 22-24 indicate that the vane dikes reduced velocities in the lower lock approach and reduced the velocity of the eddy in the lock canal. The turbulence at the end of the guard wall for low flows and the 65,000-cfs flow unevenly distributed through the gated dam was reduced. The dikes also stabilized the erratic currents at the bridge caused by the flow unevenly distributed through the dam.

50. In the upper pool, navigation conditions were relatively unchanged from Plan C. The protection cells were not required for navigation but

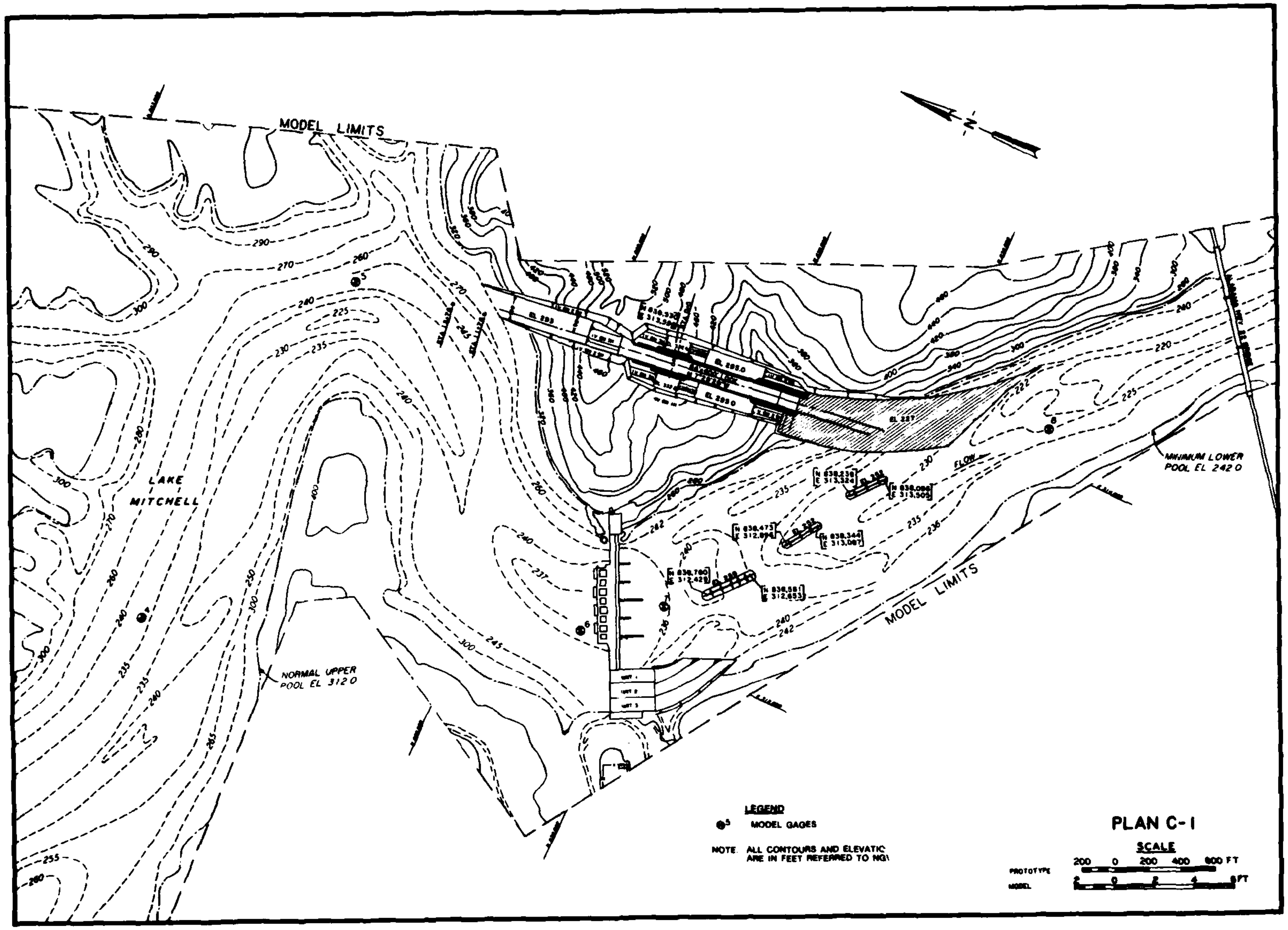

Figure 13. Plan C-1

provided a factor of safety, giving a tow something to align with and to land on if needed.

51. Navigation conditions for downbound tows in the lower pool did not significantly change compared with Plan C. For upbound tows, the dikes improved navigation conditions with the low flows and the 65,000-cfs flow unevenly distributed through the gated dam allowing upbound tows to navigate into the locks with a minimum amount of maneuvering. With the 130,000- and 175,000-cfs flows, navigation conditions at the bridge were hazardous even for tows with sufficient power to navigate the high-velocity currents. This was due to the limited clearance through the bridge with medium to high flows and the alignment of the tow approaching the bridge.

52. Surges created by lock filling and emptying and the start of powerhouse releases may seriously affect navigation. Surge data were taken at three stations with Plan C-1. Sta 1, 2, and 3 were located about 650 ft upstream, 1,250 ft downstream, and 3,400 ft downstream of the upper lock pintle, respectively (Figure 14). Results of these tests with the lock filling and emptying in 10 min and instantaneous powerhouse releases are shown in Plates 25-31.

53. Lock filling (Plate 25) produced a rapid drop in the lock approach canal of about 2.4 ft in the water surface and a peak velocity of 13.3 fps at the end of the upper guide wall (sta 1).* Navigation conditions were hazardous for a tow in the upper lock canal during lock filling.

54. Lock emptying was tested first with the lock emptying into the river and second with the lock emptying into the lower lock approach (Plates 26-29). With the lock emptying into the river and no riverflow, the water-surface surge was 0.4 ft or less at the end of the lower guard wall and just upstream of the bridge (sta 2 and 3, respectively). The peak velocities were about 0.5 fps at both stations. With the lock emptying into the lower lock approach, the surges at sta 3 were the same as those of river emptying; but at sta 2, the water-surface surge was increased about 1.0 ft and the peak velocity was about 4.0 fps. Navigation conditions would be hazardous for a tow approaching the end of the guard wall when emptying the lock into the lower lock approach with no flow in the river. Emptying into the river or maintaining a 35,000-cfs flow in the river eliminated the navigation problems caused by lock

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* Locations of surge stations are shown in Figure 14.

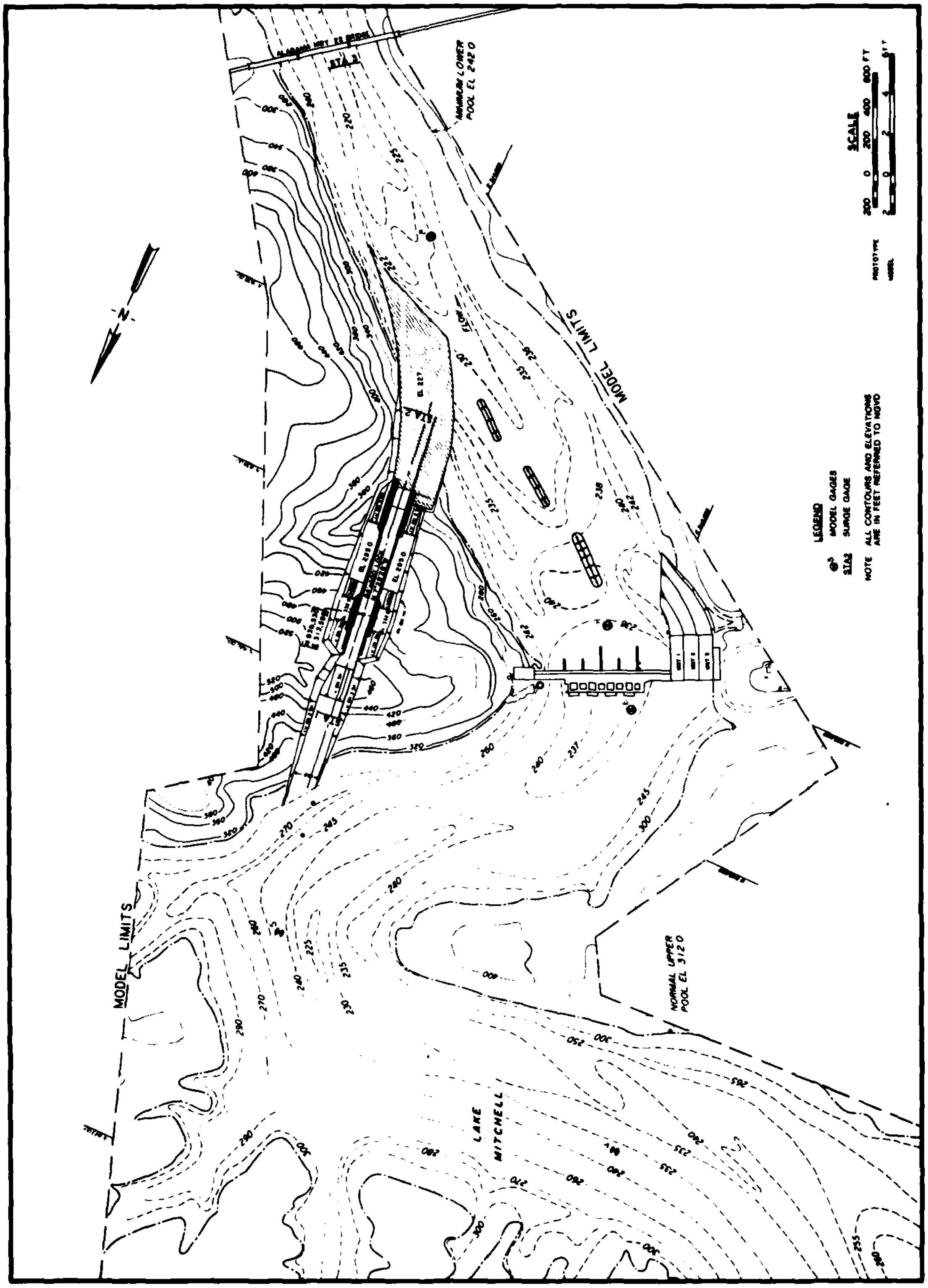


Figure 14. Location of surge stations

emptying. There was no effect on a tow at the bridge from lock emptying.

55. Powerhouse releases of 10,000 cfs (two units) and 35,000 cfs (four units) were tested with an initial tailwater el of 251.0. Starting four units simultaneously created a rise in the water surface of 1.8 ft at sta 2 and 1.5 ft at sta 3 and peak velocities of about 0.6 fps and 4.6 fps, respectively (Plates 30 and 31). Navigation was not adversely affected by the powerhouse releases.

PART IV: DISCUSSION OF RESULTS AND CONCLUSIONS

Limitation of Model Results

56. Analysis of the results of this investigation is based principally on the effects of various plans and modifications on water-surface elevations, current directions, and velocities, and the effects of the resulting currents on the behavior of the model towboat and tow. In evaluating test results, consideration should be given to the fact that small changes in direction of flow or in velocities are not necessarily changes produced by modification in plan since several floats introduced at the same point may follow different paths and move at slightly different velocities because of pulsating currents and eddies. Current directions and velocities shown in the plates were obtained with floats submerged to a depth of a loaded barge (9 ft prototype) and are indicative of the currents that would affect the behavior of tows.

57. The small scale of the model made it difficult to reproduce accurately the hydraulic characteristics of the prototype structures, measure small discharges, or measure water-surface elevations within an accuracy greater than ±0.1 ft prototype. Prototype data for model adjustment and for use in reproducing typical prototype operations were limited. The model was adjusted and operated using a tailwater rating curve with a 251.0 minimum elevation furnished by the Mobile District. Rates of lock filling and emptying were based on computed curves. Effects of weather conditions were not considered in the evaluation of results. Also, effects of closing down the power units on navigation conditions were not determined.

58. In spite of the above limitations, the model provided a reasonably adequate indication of effects that can be expected based on the conditions imposed on the model.

Summary of Results and Conclusions

59. Results of the investigation and the conclusions indicated that:

a. With medium to high flows, navigation conditions at the Highway 22 Bridge were hazardous for both upbound and downbound tows due to the high velocities and limited clearance provided through the navigation span with the existing piers and low superstructure. Navigation conditions were acceptable at the bridge for low flows.

b. With the first lock alignment (Plans A and A-1), navigation conditions were acceptable with the 35,000-cfs flow only. With flows greater than 35,000 cfs, navigation conditions were hazardous in the upper pool due to the upstream guard wall perpendicularly intersecting the currents.

c. With the second lock alignment (Plans B, B-1, B-2, and B-3), navigation conditions were acceptable for the 35,000-cfs flow. With flows higher than 35,000 cfs, navigation conditions were hazardous in the lower pool due to the current alignment, high velocities, and the short maneuvering distance between the lock approach and the Highway 22 Bridge.

d. With the third lock alignment (Plans C and C-1), navigation conditions were acceptable for all flows evenly distributed through the gated dam up to and including the 90,000-cfs flow. With the modifications in Plan C-1, the navigation conditions were improved in the lower lock approach with the low flows and the 65,000-cfs unevenly distributed flow. Navigation conditions were hazardous with flows greater than 90,000 cfs due to the current alignment, high velocities, and the limited clearance at the Highway 22 Bridge.

e. Flows unevenly distributed through the gated dam could cause navigation problems in the lower pool.

f. Navigation conditions would be hazardous for tows in the upper lock approach canal during lock filling.

g. Navigation conditions would be hazardous for tows at the end of the lower guard wall when emptying the lock into the lower approach with no riverflow. The problem was eliminated by a riverflow of 35,000 cfs or by emptying the lock into the river.

Table 1

Base Conditions

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs				
	5,000	15,000	35,000	90,000	175,000
1	312.0	312.1	312.1	312.3	312.7
2	312.0	312.1	312.1	312.3	312.7
3	312.0	312.1	312.1	312.3	312.6
4	312.0	312.0	312.0	312.2	312.6
5	312.0	312.0	312.0	312.1	312.5
6	312.0*	312.0*	312.0*	312.0*	312.0*
7	251.1*	251.2*	251.9*	255.9*	261.7*
8	251.0	251.1	251.7	255.6	261.0
9	250.9	251.0	251.6	255.3	260.0

* Controlled elevation.

Table 2

Plan A

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs		
	35,000	90,000	175,000
1	312.1	312.3	312.7
2	312.1	312.3	312.7
3	312.1	312.3	312.7
4	312.0	312.2	312.6
5	312.0	312.1	312.5
6	312.0*	312.0*	312.0*
7	251.9	256.0	261.7
8	251.7	255.7	261.0
9	251.6*	255.3*	260.0*

* Controlled elevations.

Table 3

Plan A-1

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs		
	35,000	90,000	175,000
1	312.1	312.3	312.7
2	312.1	312.3	312.7
3	312.1	312.3	312.7
4	312.0	312.2	312.6
5	312.0	312.1	312.5
6	312.0*	312.0*	312.0*
7	251.9	256.0	261.7
8	251.7	255.7	261.0
9	251.6*	255.3*	260.0*

* Controlled elevations.

Table 4

Plan B

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 35,000	65,000	90,000	130,000	175,000
1	312.0	312.3	312.3	312.5	312.7
2	312.0	312.2	312.3	312.4	312.7
3	312.0	312.2	312.3	312.4	312.6
4	312.0	312.1	312.2	312.3	312.6
5	312.0	312.1	312.1	312.3	312.5
6	312.0*	312.0*	312.0*	312.0*	312.0*
7	251.9	253.7	255.9	259.0	261.8
8	251.7	253.0	255.7	258.5	261.1
9	251.6*	252.7*	255.3*	257.4*	260.0*

* Controlled elevation.

Table 5

Plan B-1

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 35,000	90,000	175,000
1	312.0	312.3	312.7
2	312.0	312.3	312.7
3	312.0	312.3	312.6
4	312.0	312.2	312.6
5	312.0	312.1	312.5
6	312.0*	312.0*	312.0*
7	251.9	255.9	261.8
8	251.7	255.7	261.1
9	251.6*	255.3*	260.0*

* Controlled elevations.

Table 6

Plan B-2

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 35,000	90,000	175,000
1	312.0	312.3	312.7
2	312.0	312.3	312.7
3	312.0	312.3	312.6
4	312.0	312.2	312.6
5	312.0	312.1	312.5
6	312.0*	312.0*	312.0*
7	251.9	255.9	261.8
8	251.7	255.7	261.1
9	251.6*	255.3*	260.0*

* Controlled elevations.

Table 7

Plan B-3

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 35,000	90,000	175,000
1	312.1	312.3	312.7
2	312.1	312.3	312.7
3	312.1	312.3	312.7
4	312.0	312.2	312.6
5	312.0	312.1	312.5
6	312.0*	312.0*	312.0*
7	251.9	255.9	261.8
8	251.7	255.7	261.1
9	251.6*	255.3*	260.0*

* Controlled elevations.

Table 8

Plan C

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 15,000	35,000	65,000	90,000	130,000	175,000
1	312.1	312.1	312.3	312.3	312.5	312.7
2	312.1	312.1	312.2	312.3	312.4	312.7
3	312.1	312.1	312.2	312.3	312.4	312.6
4	312.0	312.0	312.1	312.2	312.3	312.6
5	312.0	312.0	312.1	312.1	312.3	312.5
6	312.0*	312.0*	312.0*	312.0*	312.0*	312.0*
7	251.2	251.9	253.4	256.3	259.1	262.2
8	251.1	251.8	253.0	255.9	258.5	261.7
9	251.0*	251.6*	252.7*	255.3*	257.4*	260.0*

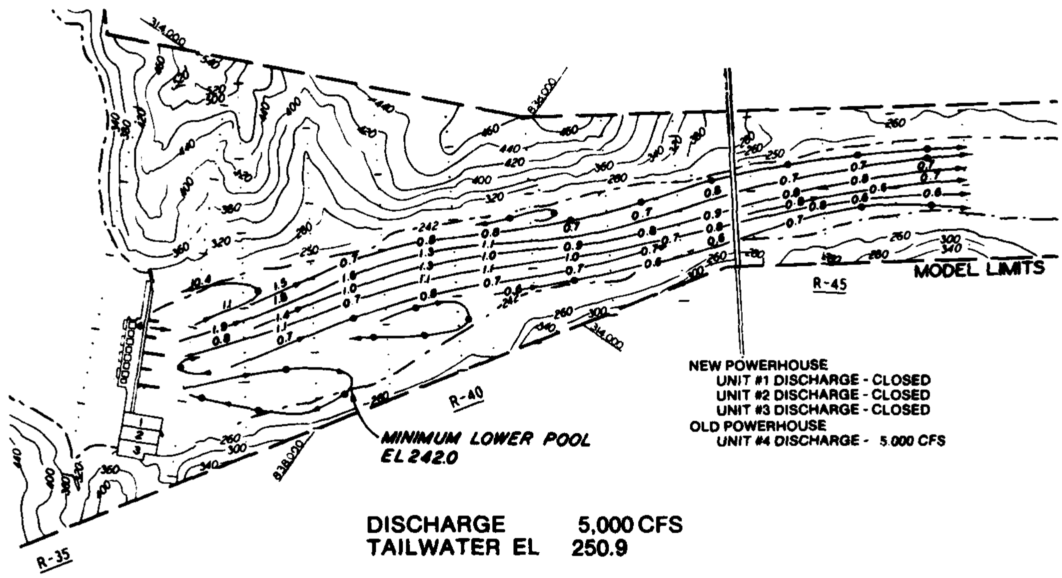
* Controlled elevations.

Table 9

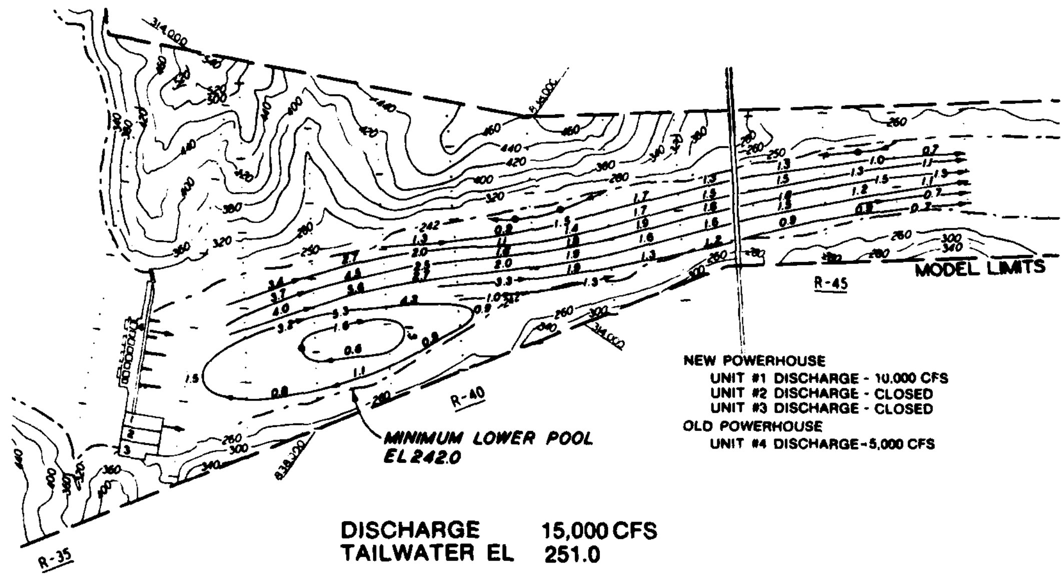
Plan C-1

Gage No.	Water-Surface Elevations, ft NGVD, for Discharge, cfs 15,000	35,000	65,000	90,000	130,000	175,000
1	312.1	312.1	312.3	312.3	312.5	312.7
2	312.1	312.1	312.2	312.3	312.4	312.7
3	312.1	312.1	312.2	312.3	312.4	312.6
4	312.0	312.0	312.1	312.2	312.3	312.6
5	312.0	312.0	312.1	312.1	312.3	312.5
6	312.0*	312.0*	312.0*	312.0*	312.0*	312.0*
7	251.2	251.9	253.5	256.5	259.2	262.3
8	251.1	251.7	253.1	255.9	258.5	261.7
9	251.0*	251.6*	252.7*	255.3*	257.4*	260.0*

* Controlled elevations.



DISCHARGE 5,000 CFS
TAILWATER EL 250.9



DISCHARGE 15,000 CFS
TAILWATER EL 251.0

LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

VELOCITIES AND CURRENT DIRECTIONS

BASE CONDITIONS

DISCHARGES 5,000 AND 15,000 CFS

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

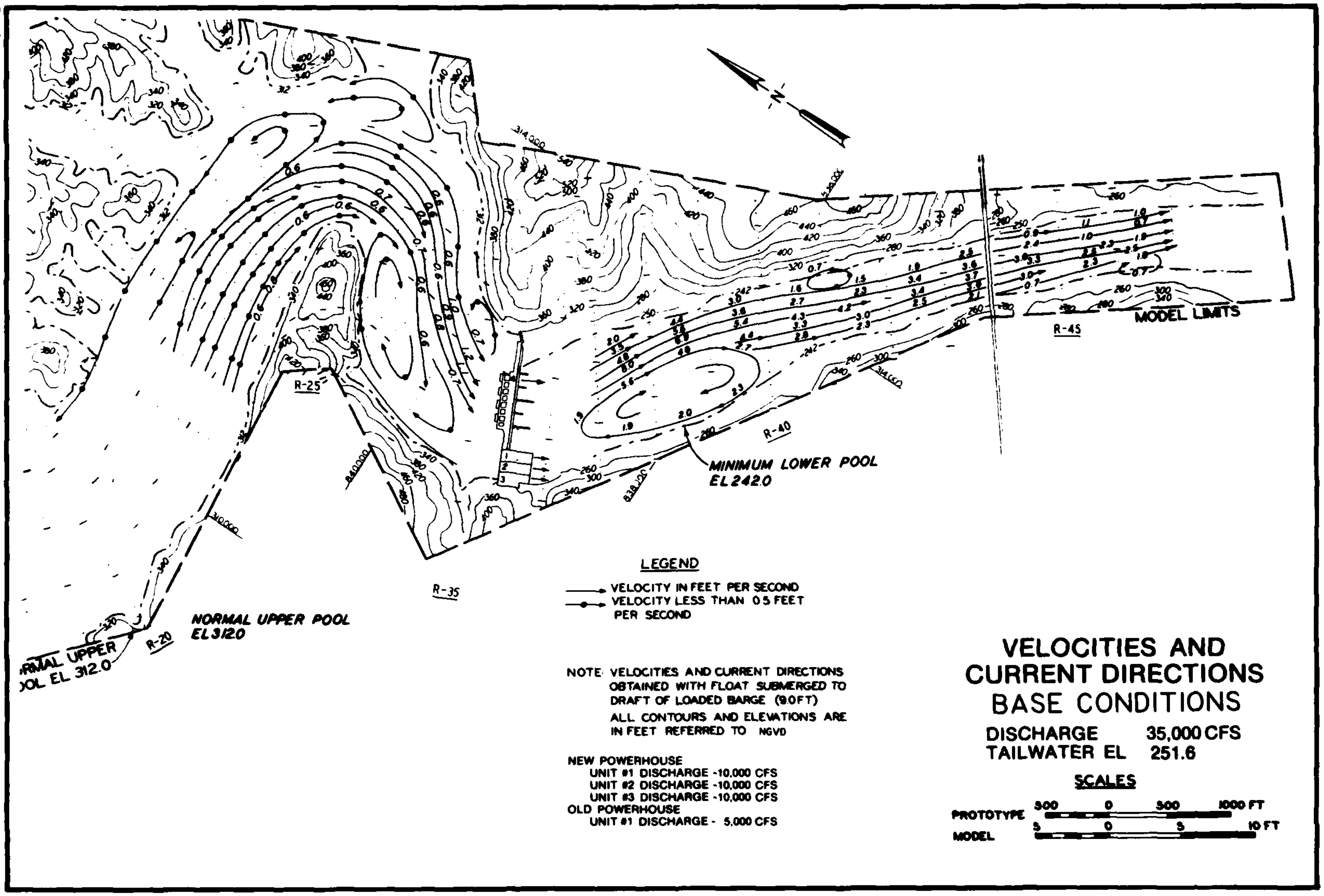

VELOCITIES AND
CURRENT DIRECTIONS
BASE CONDITIONS
DISCHARGE 35,000 CFS
TAILWATER EL 251.6
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE -10,000 CFS
UNIT #2 DISCHARGE -10,000 CFS
UNIT #3 DISCHARGE -10,000 CFS
OLD POWERHOUSE
UNIT #1 DISCHARGE - 5,000 CFS
NORMAL UPPER POOL
EL 312.0
MINIMUM LOWER POOL
EL 242.0
MODEL LIMITS
R-20
R-25
R-35
R-40
R-45
N

PLATE 2

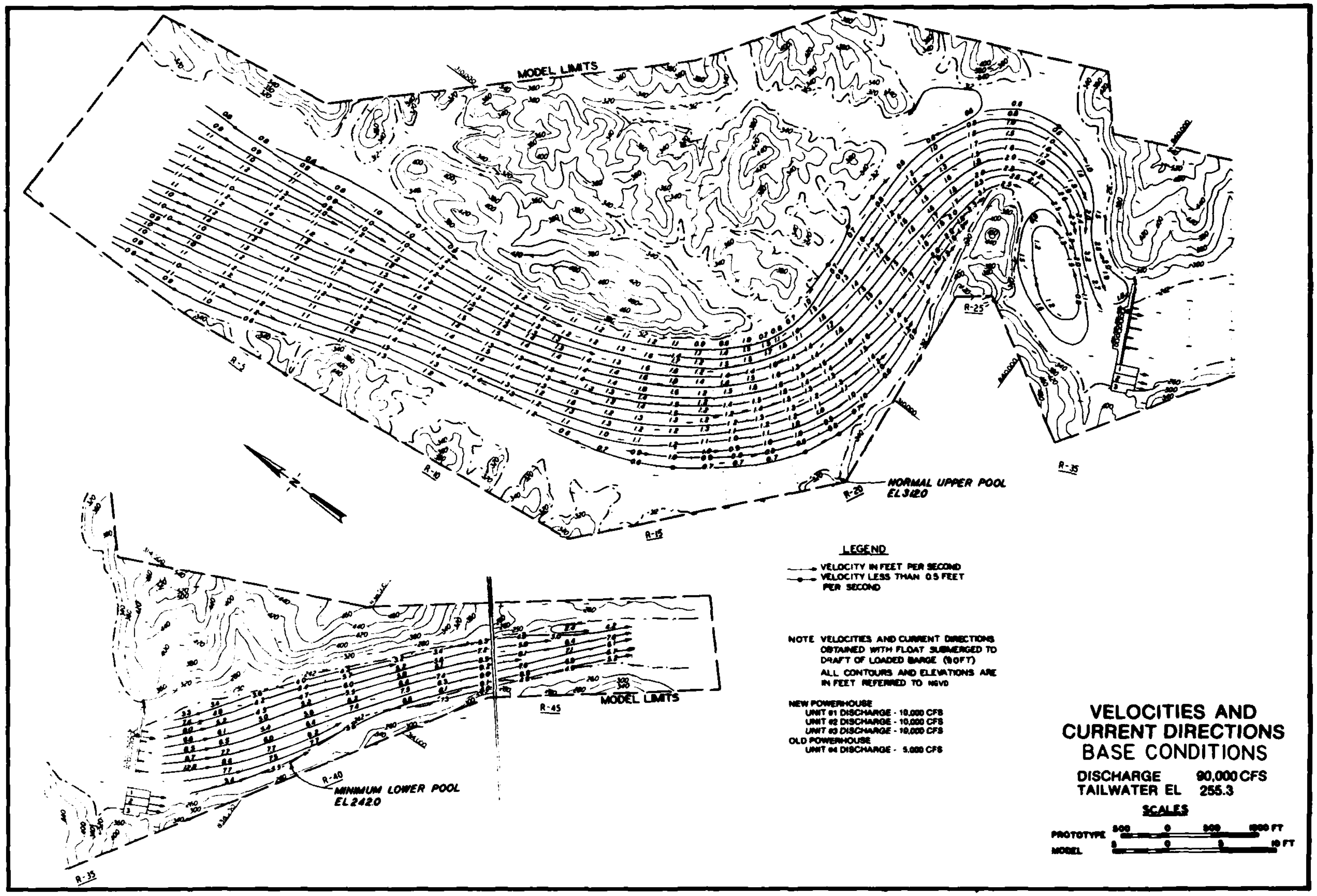

MODEL LIMITS
NORMAL UPPER POOL
EL 312.0
MINIMUM LOWER POOL
EL 242.0
MODEL LIMITS
R-5
R-10
R-15
R-20
R-25
R-35
R-35
R-40
R-45
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
VELOCITIES AND
CURRENT DIRECTIONS
BASE CONDITIONS
DISCHARGE 90,000 CFS
TAILWATER EL 255.3
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 3

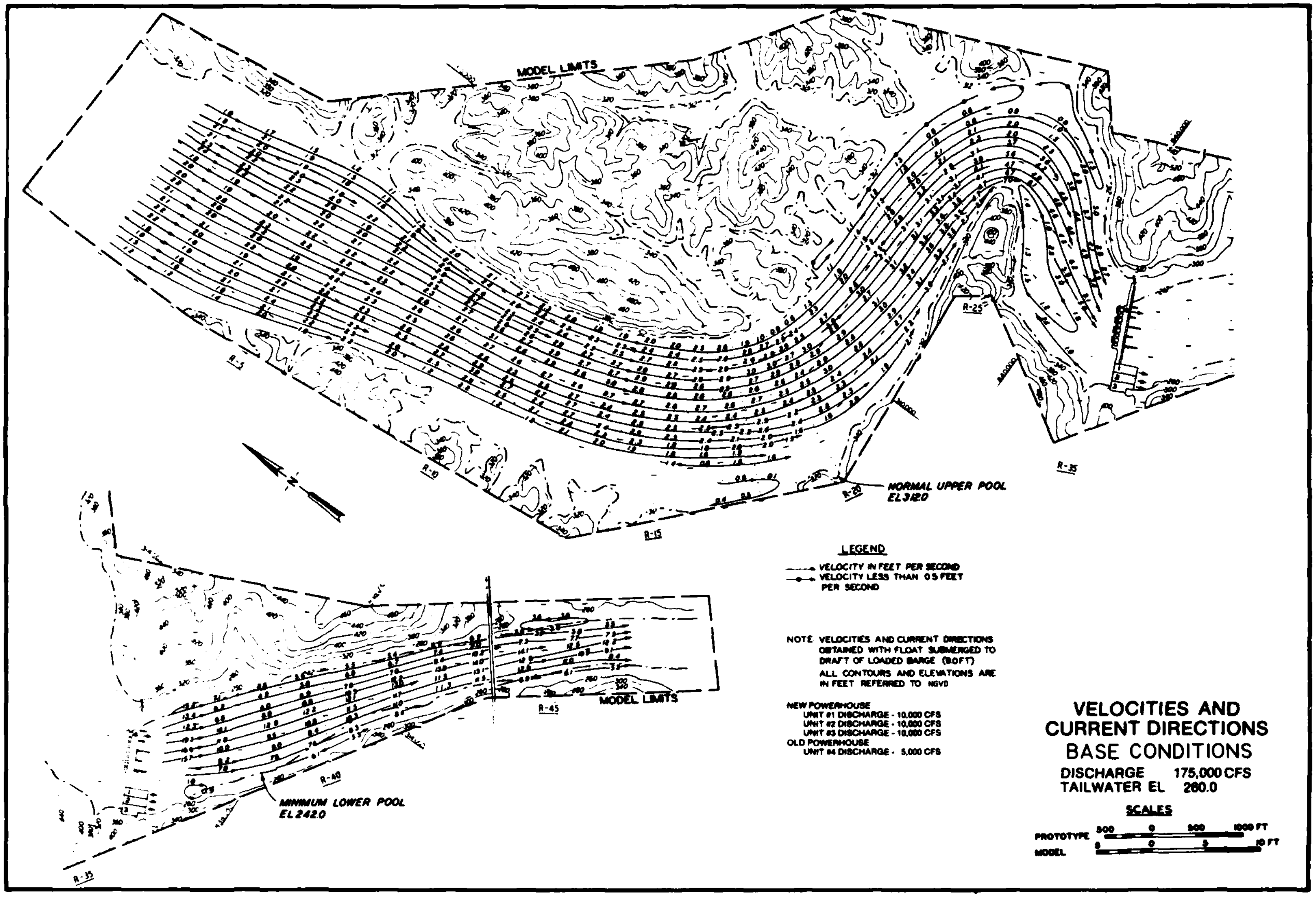

VELOCITIES AND
CURRENT DIRECTIONS
BASE CONDITIONS
DISCHARGE 175,000 CFS
TAILWATER EL 260.0
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
MODEL LIMITS
NORMAL UPPER POOL
EL 312.0
MINIMUM LOWER POOL
EL 242.0
R-5
R-10
R-15
R-20
R-25
R-35
R-40
R-45

PLATE 4

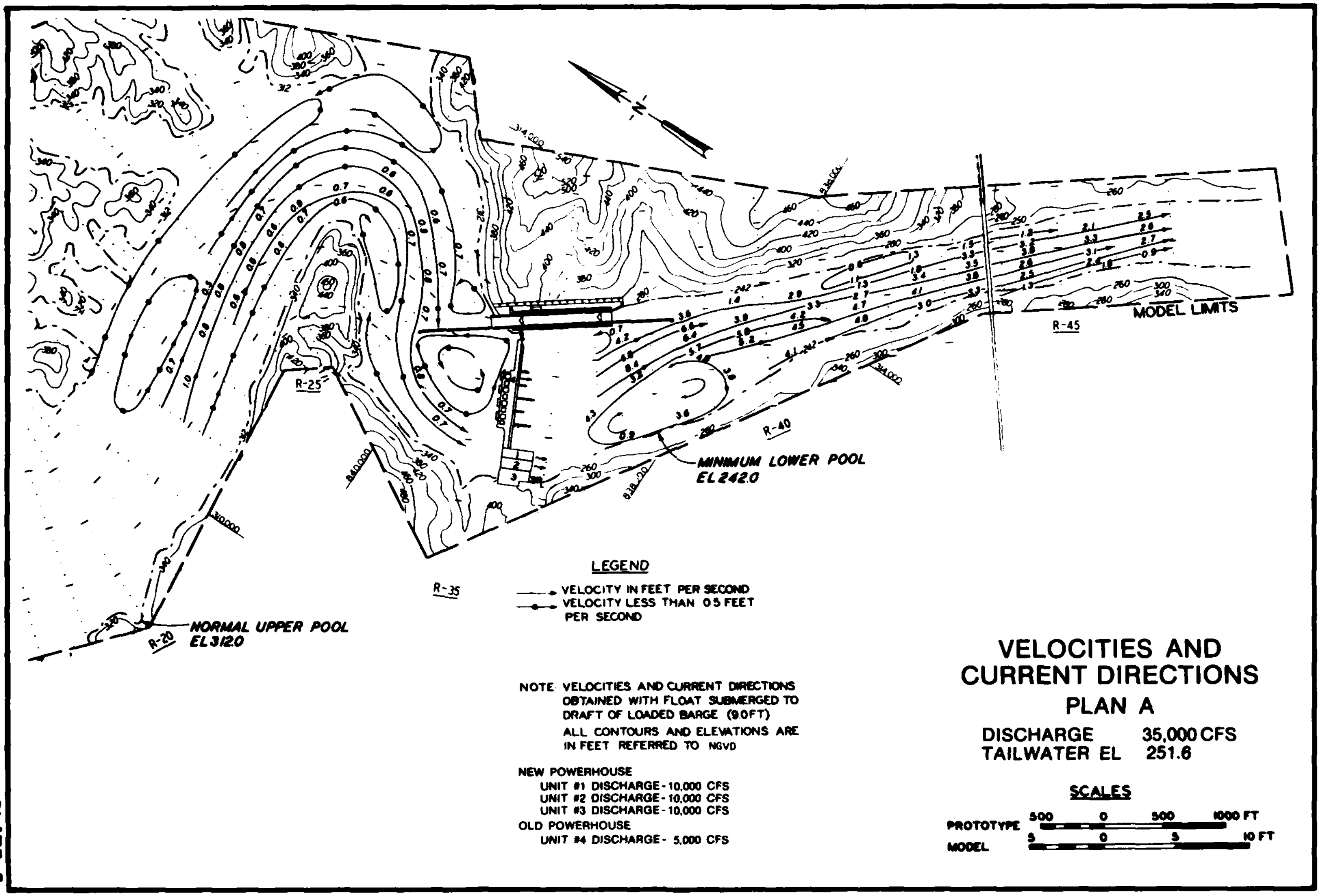
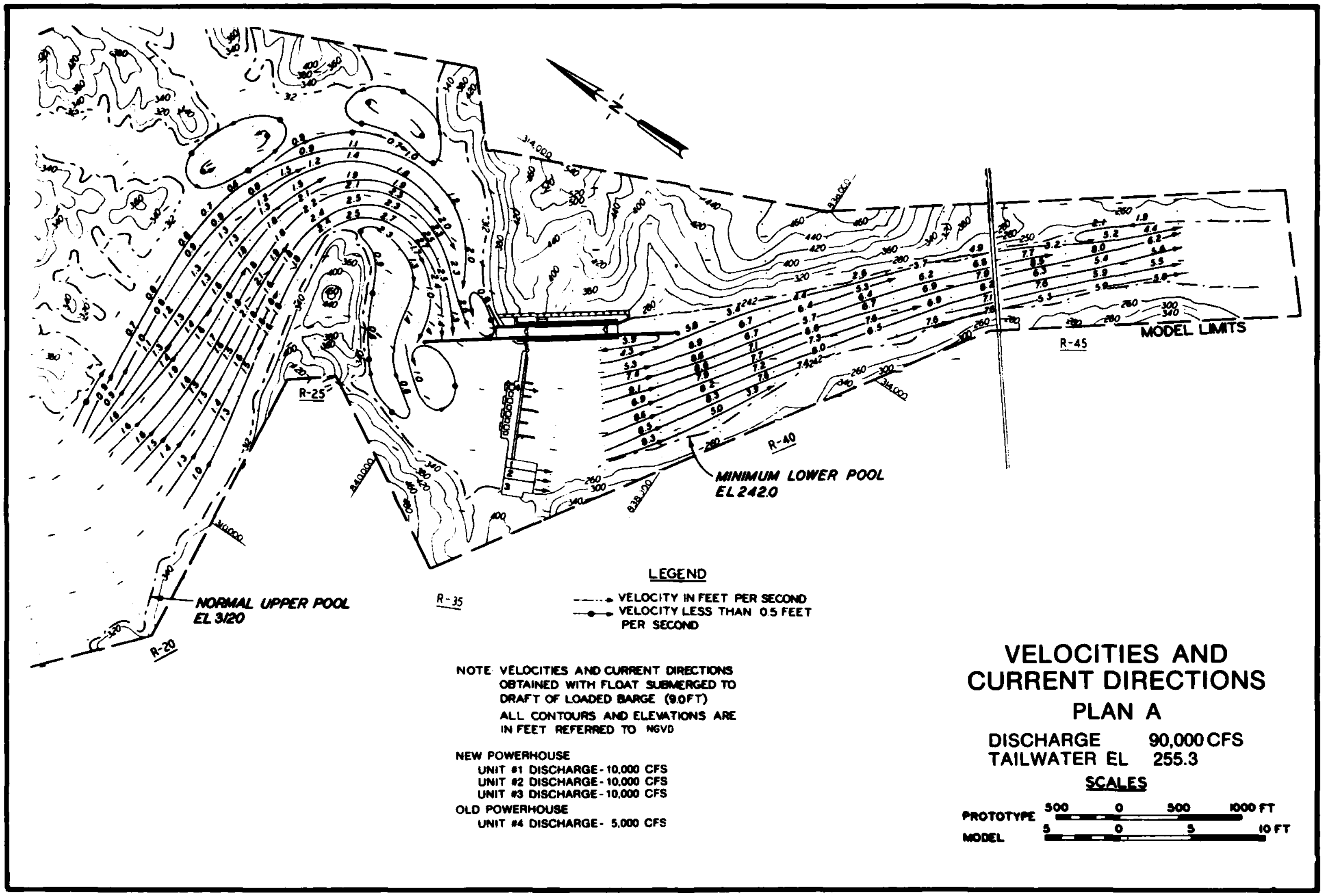
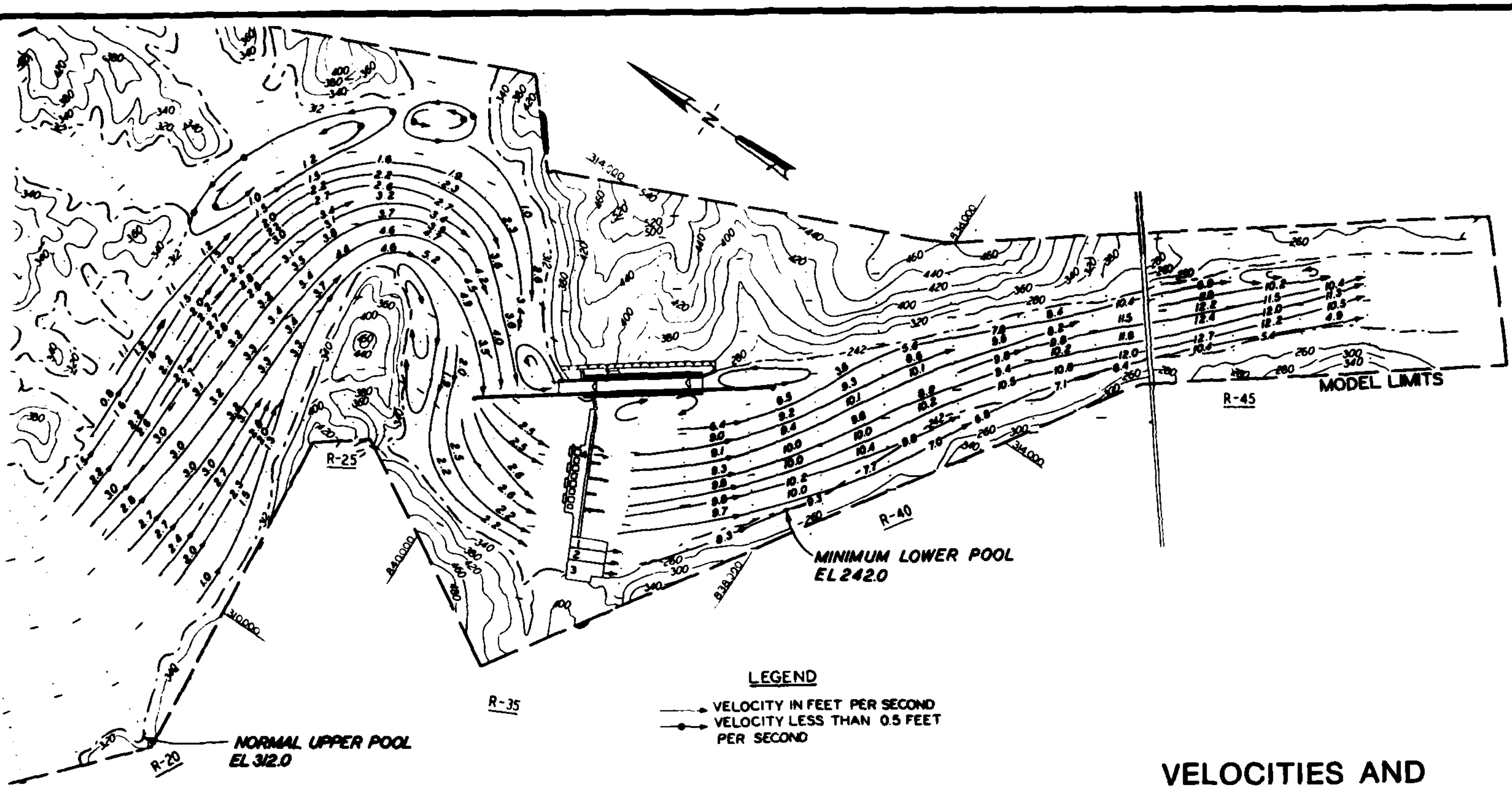

VELOCITIES AND
CURRENT DIRECTIONS
PLAN A
DISCHARGE 35,000 CFS
TAILWATER EL 251.6
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
NORMAL UPPER POOL
EL 312.0
MINIMUM LOWER POOL
EL 242.0
MODEL LIMITS
R-20
R-25
R-35
R-40
R-45
N

PLATE 5



VELOCITIES AND CURRENT DIRECTIONS
PLAN A
DISCHARGE 90,000 CFS
TAILWATER EL 255.3
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
NORMAL UPPER POOL EL 312.0
MINIMUM LOWER POOL EL 242.0
MODEL LIMITS
R-20
R-25
R-35
R-40
R-45
N

PLATE 6



LEGEND

→ VELOCITY IN FEET PER SECOND
•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS

VELOCITIES AND CURRENT DIRECTIONS
PLAN A

DISCHARGE 175,000 CFS
TAILWATER EL 260.0

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

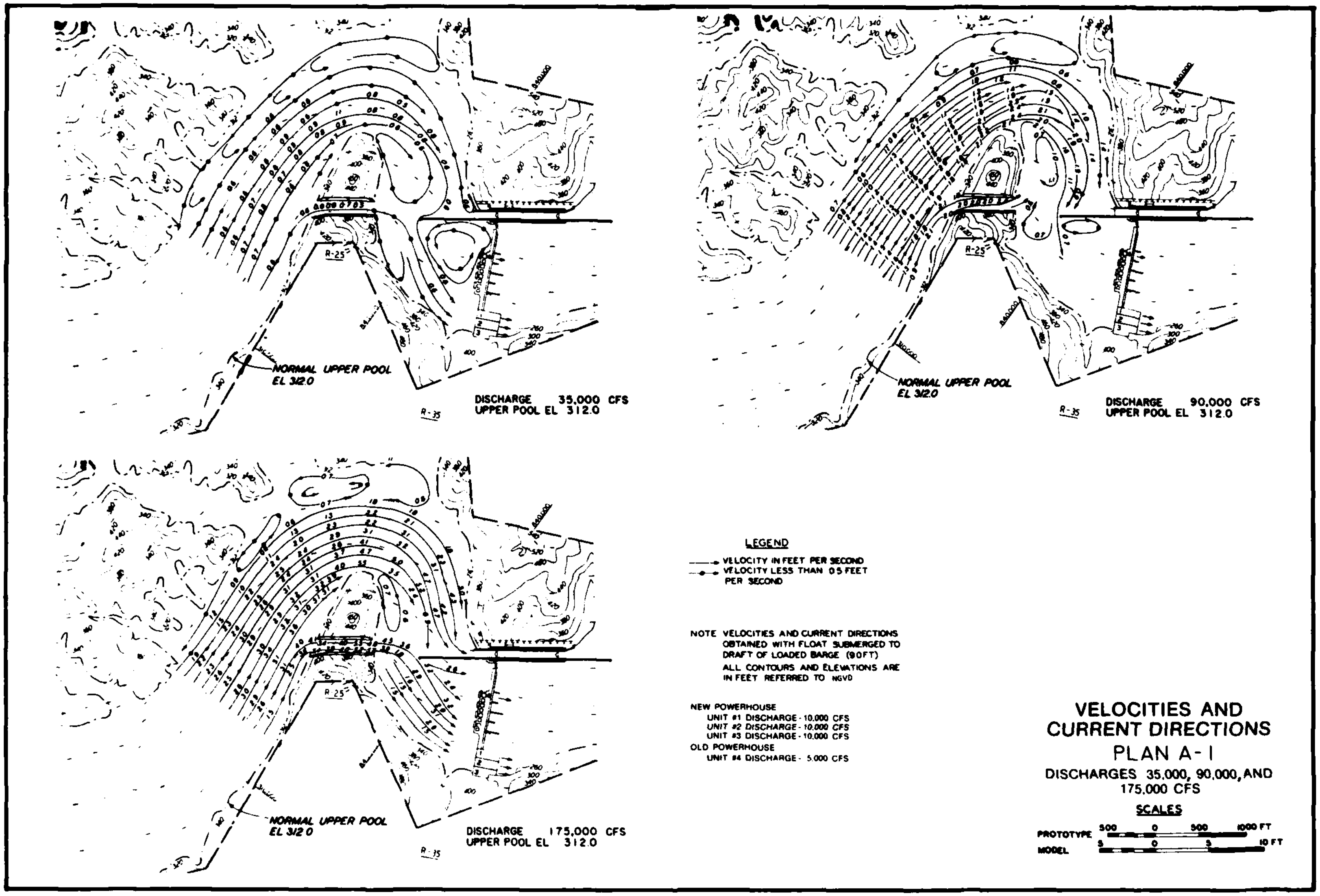
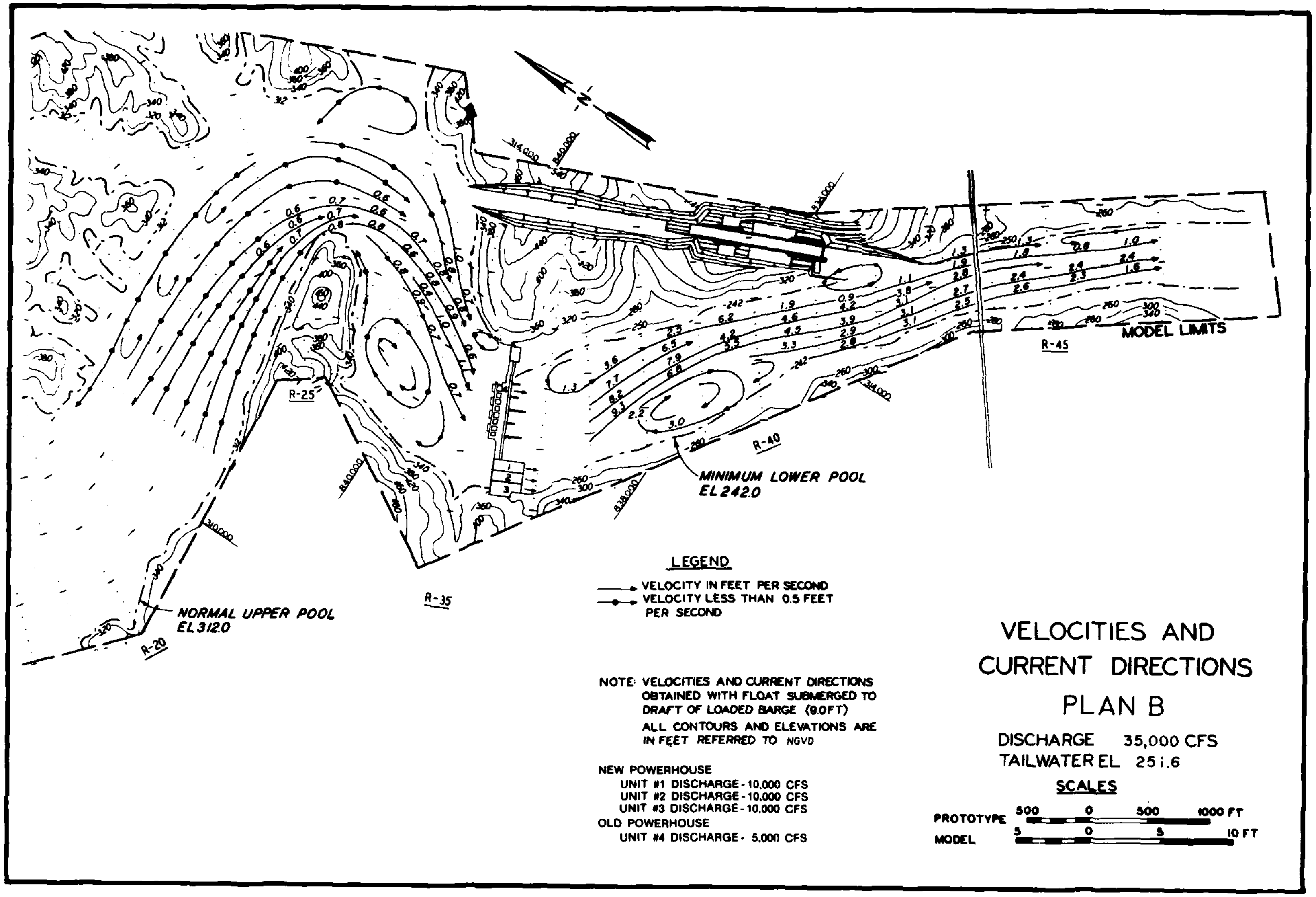

NORMAL UPPER POOL EL 312.0
DISCHARGE 35,000 CFS
UPPER POOL EL 312.0
DISCHARGE 90,000 CFS
UPPER POOL EL 312.0
DISCHARGE 175,000 CFS
UPPER POOL EL 312.0
R-25
R-35
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
VELOCITIES AND CURRENT DIRECTIONS
PLAN A-1
DISCHARGES 35,000, 90,000, AND 175,000 CFS
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 8



VELOCITIES AND CURRENT DIRECTIONS
PLAN B
DISCHARGE 35,000 CFS
TAILWATER EL 251.6
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
NORMAL UPPER POOL
EL 312.0
MINIMUM LOWER POOL
EL 242.0
MODEL LIMITS
R-20
R-25
R-35
R-40
R-45

PLATE 9

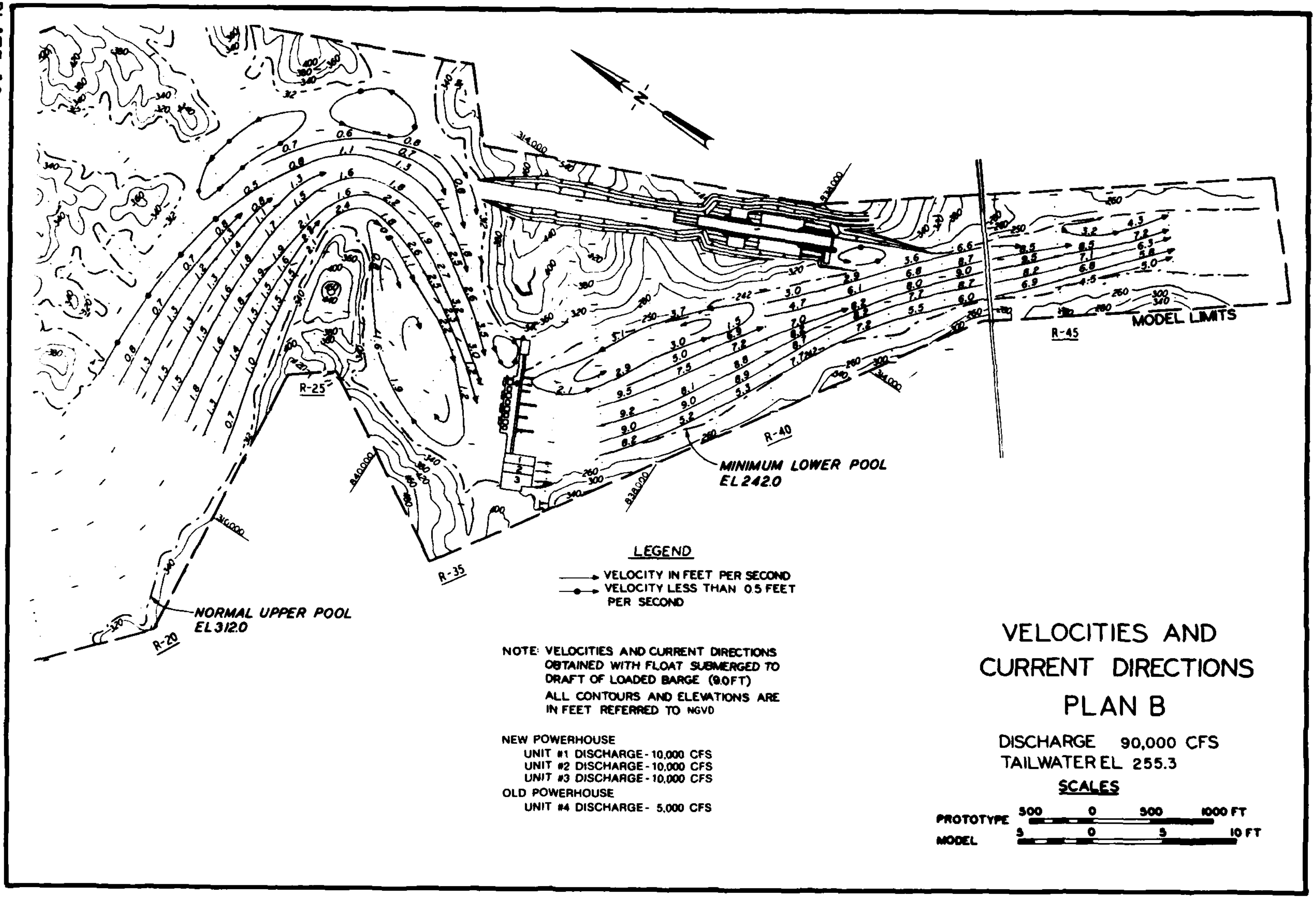
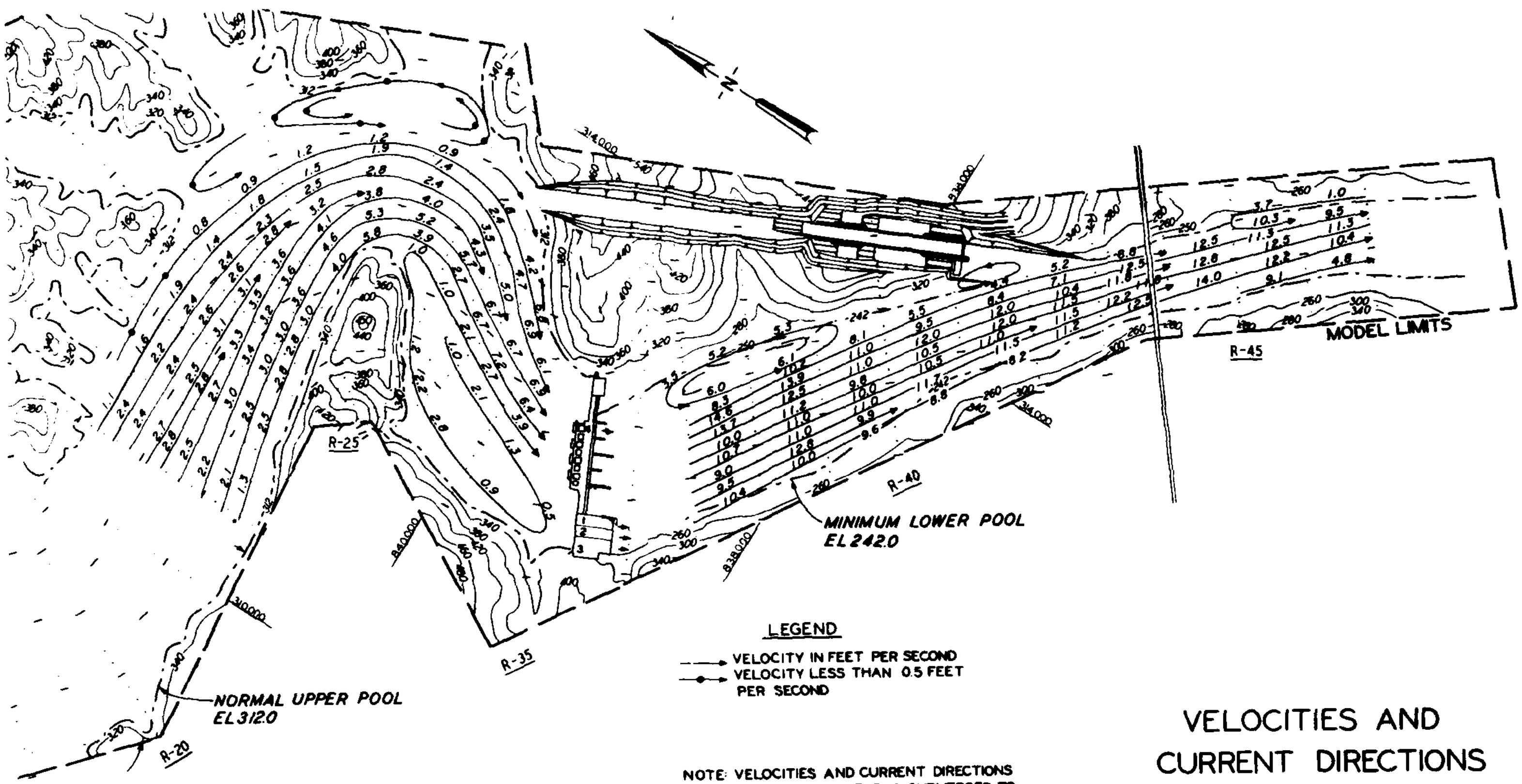

N
MINIMUM LOWER POOL
EL 242.0
NORMAL UPPER POOL
EL 312.0
MODEL LIMITS
R-20
R-25
R-35
R-40
R-45
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS
VELOCITIES AND
CURRENT DIRECTIONS
PLAN B
DISCHARGE 90,000 CFS
TAILWATER EL 255.3
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 10



LEGEND

→ VELOCITY IN FEET PER SECOND
•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS

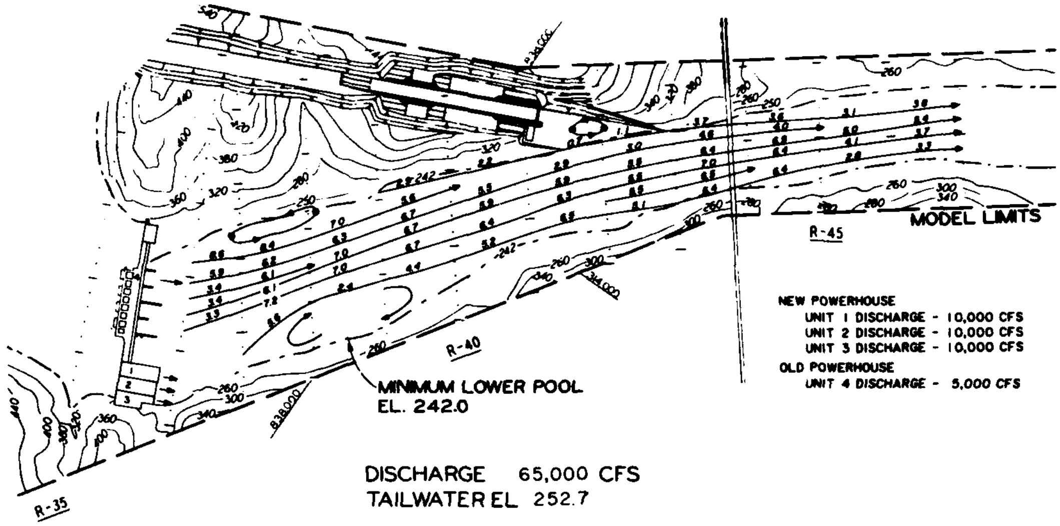
VELOCITIES AND CURRENT DIRECTIONS

PLAN B

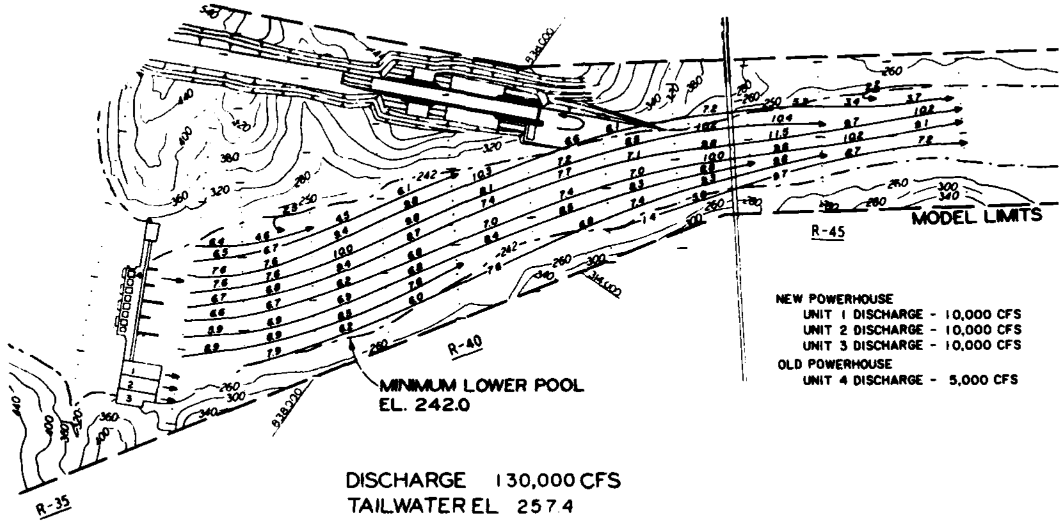
DISCHARGE 175,000 CFS
TAILWATER EL 260.0

SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT



DISCHARGE 65,000 CFS
TAILWATER EL 252.7



DISCHARGE 130,000 CFS
TAILWATER EL 257.4

LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

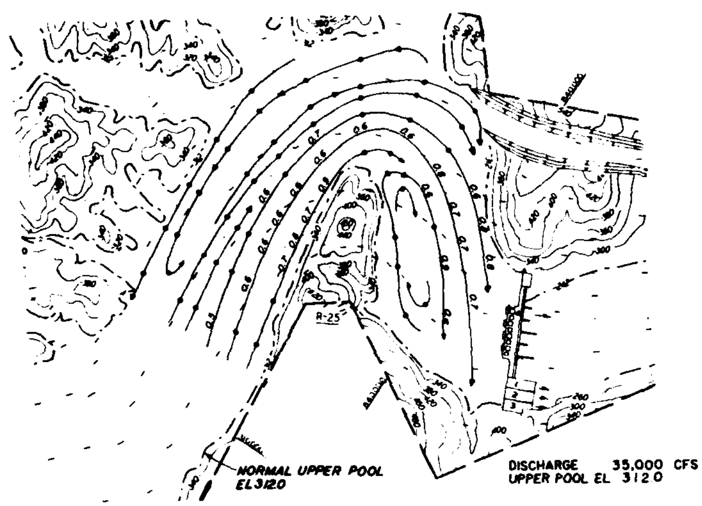
VELOCITIES AND CURRENT DIRECTIONS

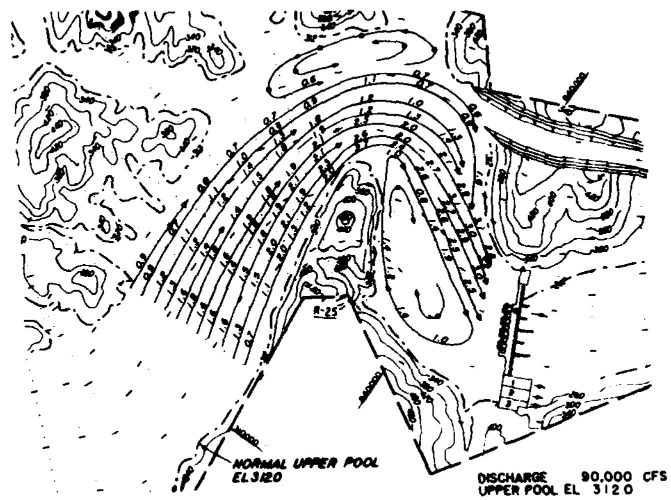
PLAN B

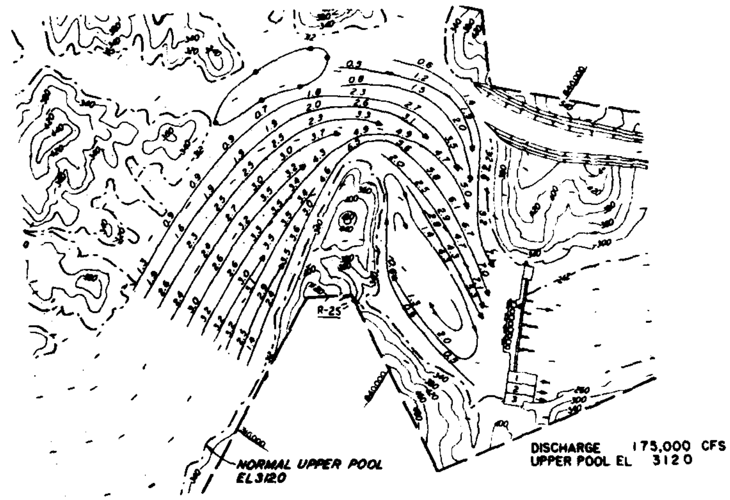
DISCHARGES 65,000 AND 130,000 CFS

SCALES

PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT







LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT #1 DISCHARGE - 10,000 CFS
UNIT #2 DISCHARGE - 10,000 CFS
UNIT #3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT #4 DISCHARGE - 5,000 CFS

VELOCITIES AND CURRENT DIRECTIONS

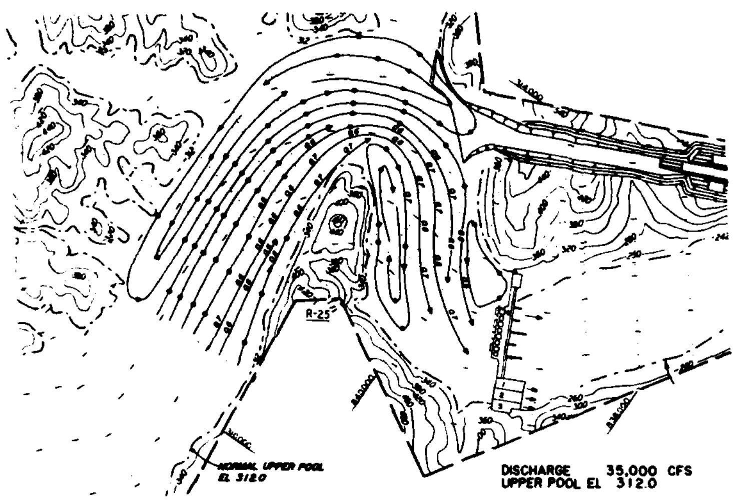
PLAN B-1

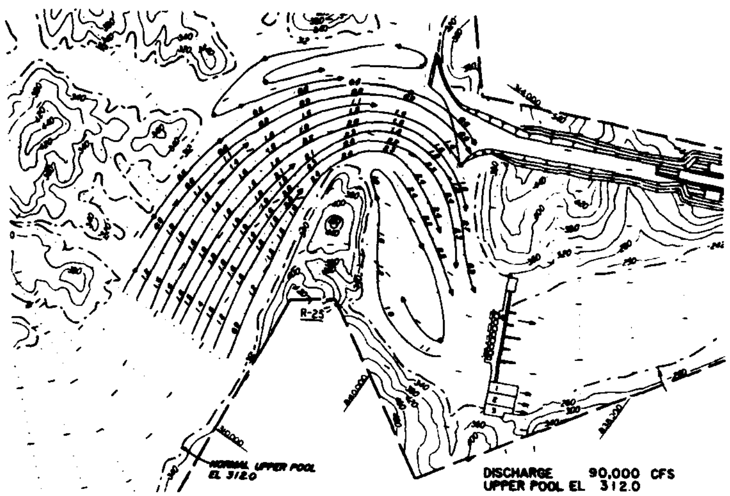
DISCHARGES 35,000, 90,000 AND 175,000 CFS

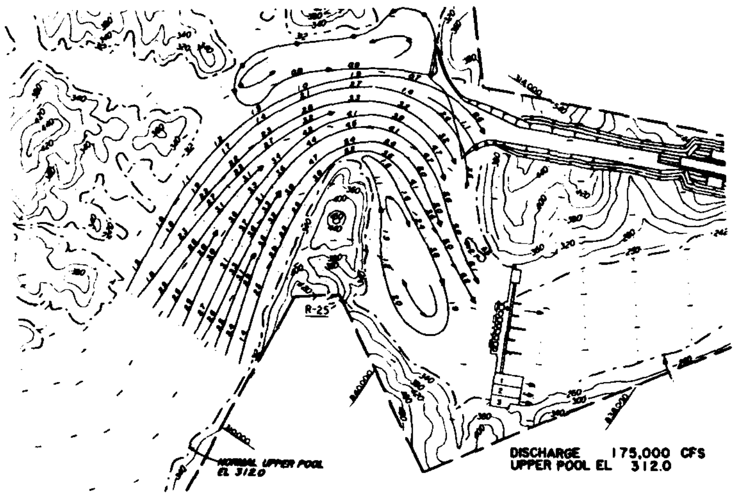
SCALES

PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 13







LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT 1 DISCHARGE - 10,000 CFS
UNIT 2 DISCHARGE - 10,000 CFS
UNIT 3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE - 5,000 CFS

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2

DISCHARGES 35,000, 90,000 AND 175,000 CFS

SCALES

PROTOTYPE 300 0 300 600 FT

MODEL 3 0 3 6 FT

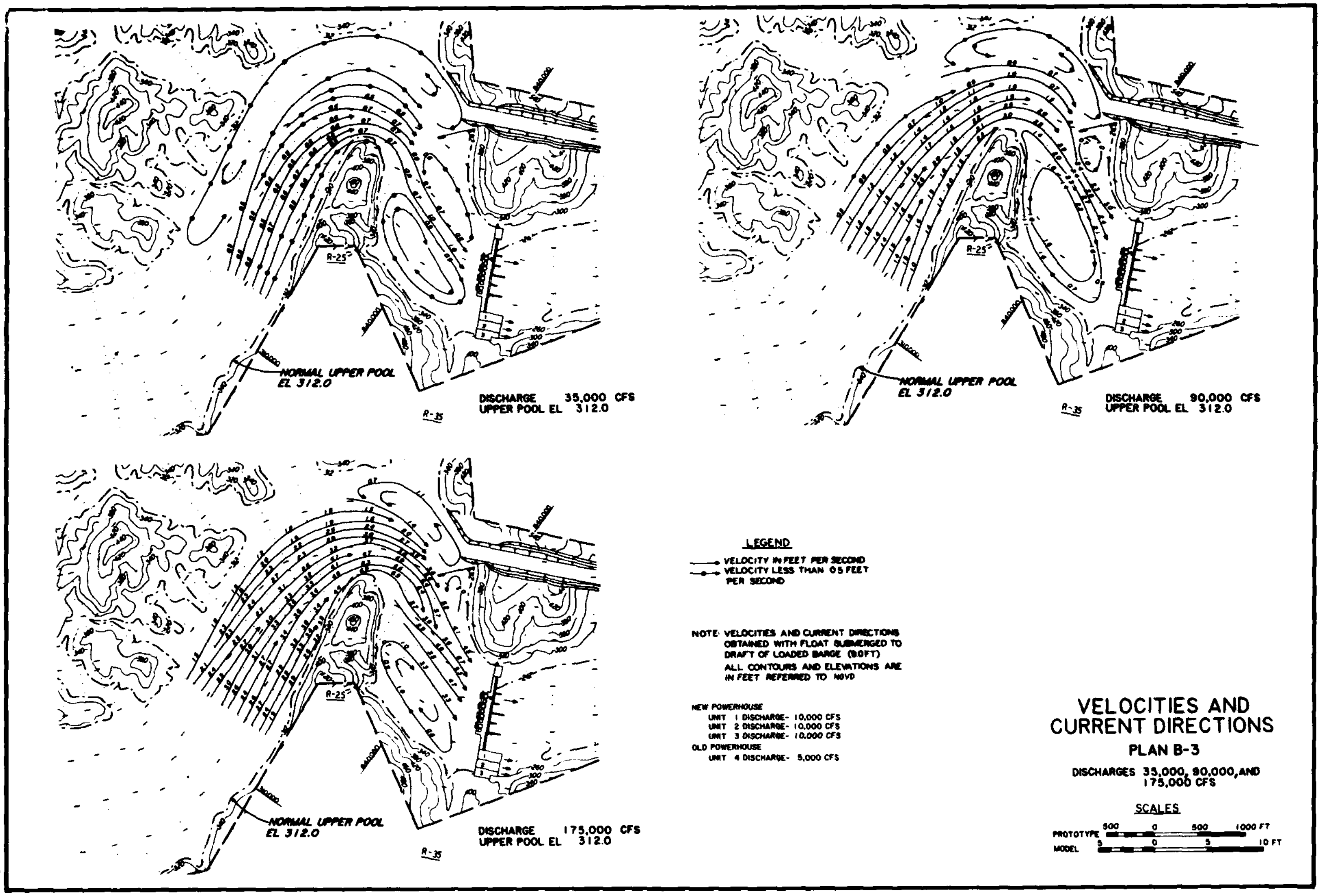
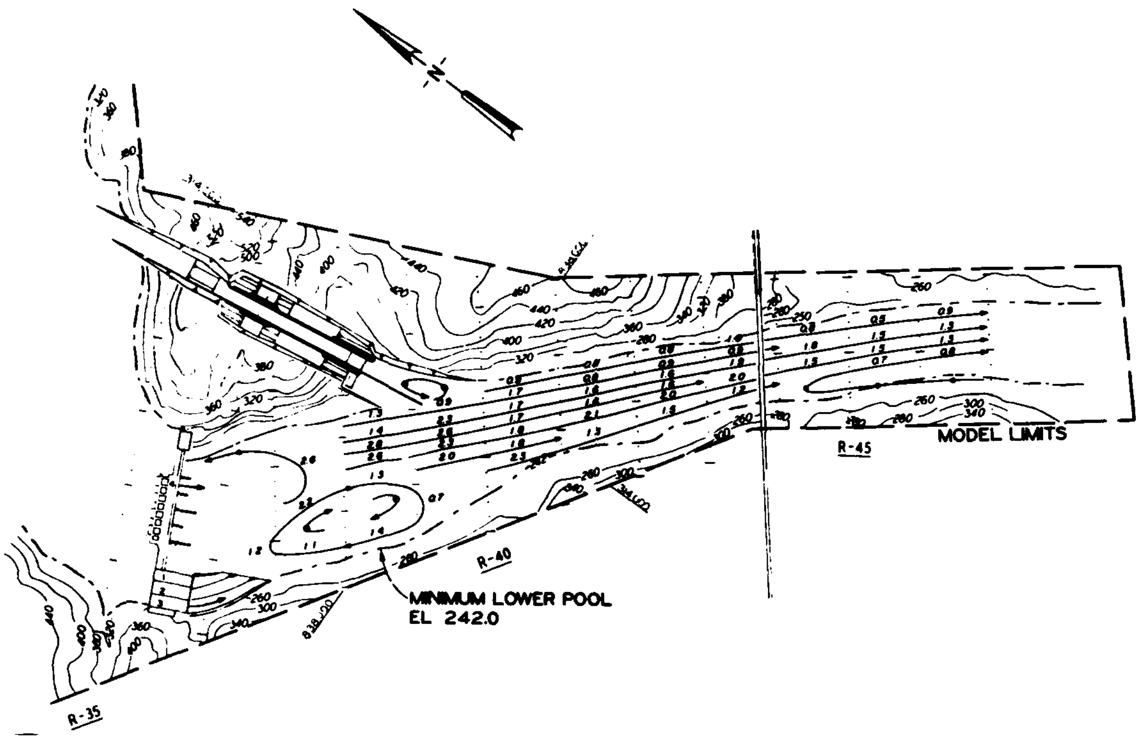

NORMAL UPPER POOL EL 312.0
DISCHARGE 35,000 CFS
UPPER POOL EL 312.0
DISCHARGE 90,000 CFS
UPPER POOL EL 312.0
DISCHARGE 175,000 CFS
UPPER POOL EL 312.0
R-25
R-35
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT 1 DISCHARGE - 10,000 CFS
UNIT 2 DISCHARGE - 10,000 CFS
UNIT 3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE - 5,000 CFS
VELOCITIES AND CURRENT DIRECTIONS
PLAN B-3
DISCHARGES 35,000, 90,000, AND 175,000 CFS
SCALES
PROTOTYPE 500 0 500 1000 FT
MODEL 5 0 5 10 FT

PLATE 15



LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT 1 DISCHARGE - CLOSED
UNIT 2 DISCHARGE - CLOSED
UNIT 3 DISCHARGE - 10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE - 5,000 CFS

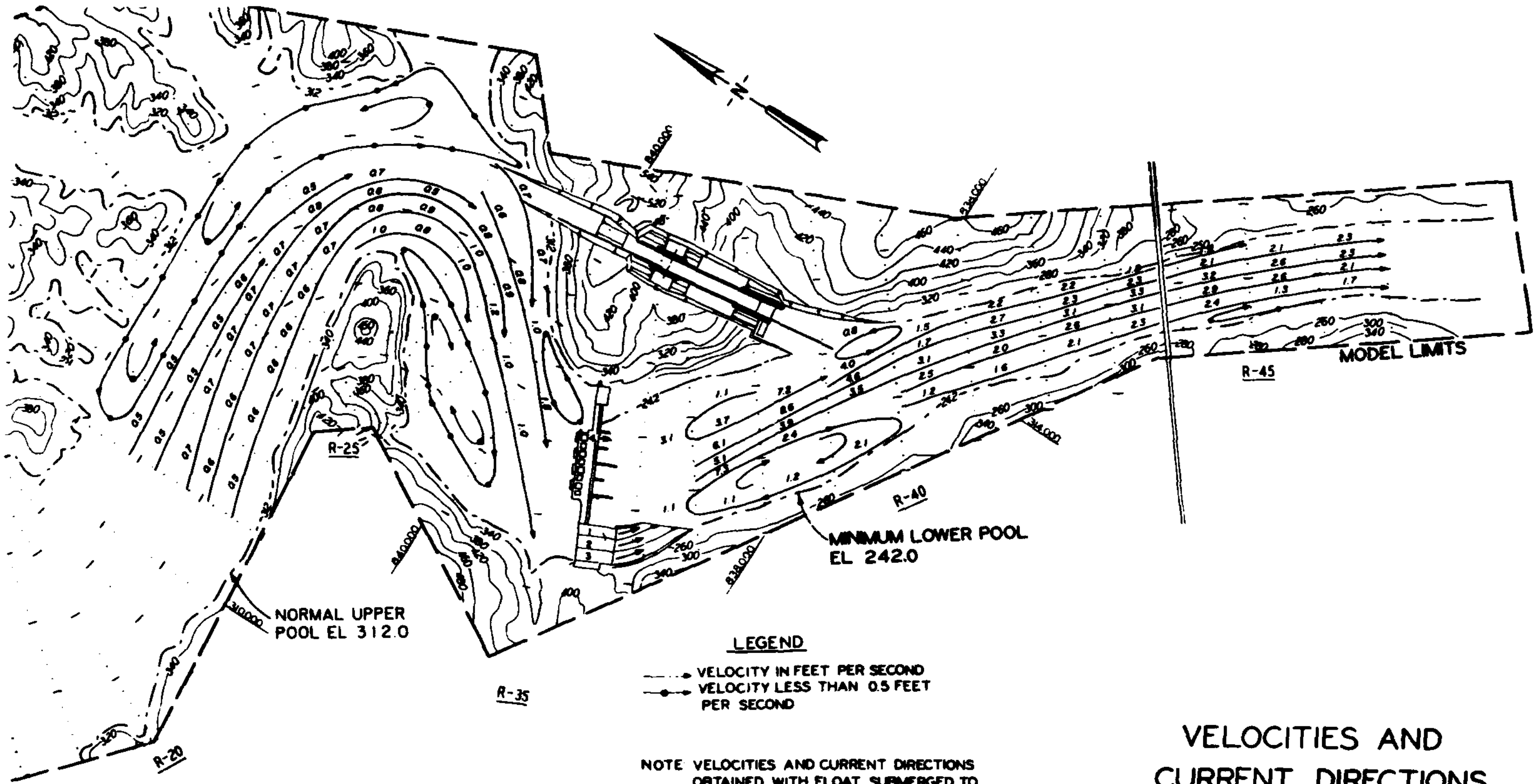
VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE 15,000 CFS
TAILWATER EL 251.0

SCALES

PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT



LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NEW POWERHOUSE
UNIT 1 DISCHARGE-10,000 CFS
UNIT 2 DISCHARGE-10,000 CFS
UNIT 3 DISCHARGE-10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE-5,000 CFS

VELOCITIES AND CURRENT DIRECTIONS
PLAN C

DISCHARGE 35,000 CFS
TAILWATER EL 251.6

SCALES

PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT

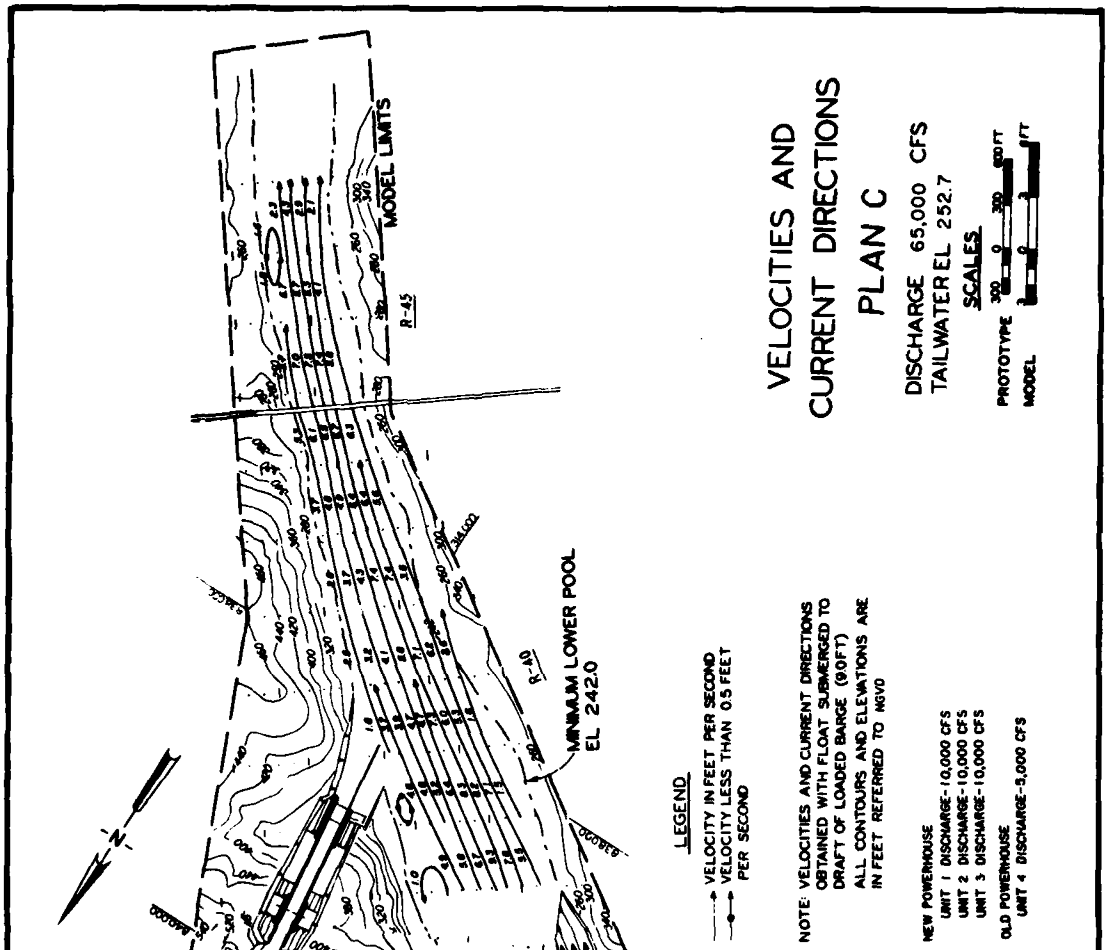

VELOCITIES AND
CURRENT DIRECTIONS
PLAN C
DISCHARGE 65,000 CFS
TAILWATER EL 252.7
SCALES
PROTOTYPE
MODEL
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT 1 DISCHARGE-10,000 CFS
UNIT 2 DISCHARGE-10,000 CFS
UNIT 3 DISCHARGE-10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE-5,000 CFS
MINIMUM LOWER POOL EL 242.0
NORMAL UPPER POOL EL 312.0
MODEL LIMITS
R-45
R-40
R-25
R-20
N

PLATE 18

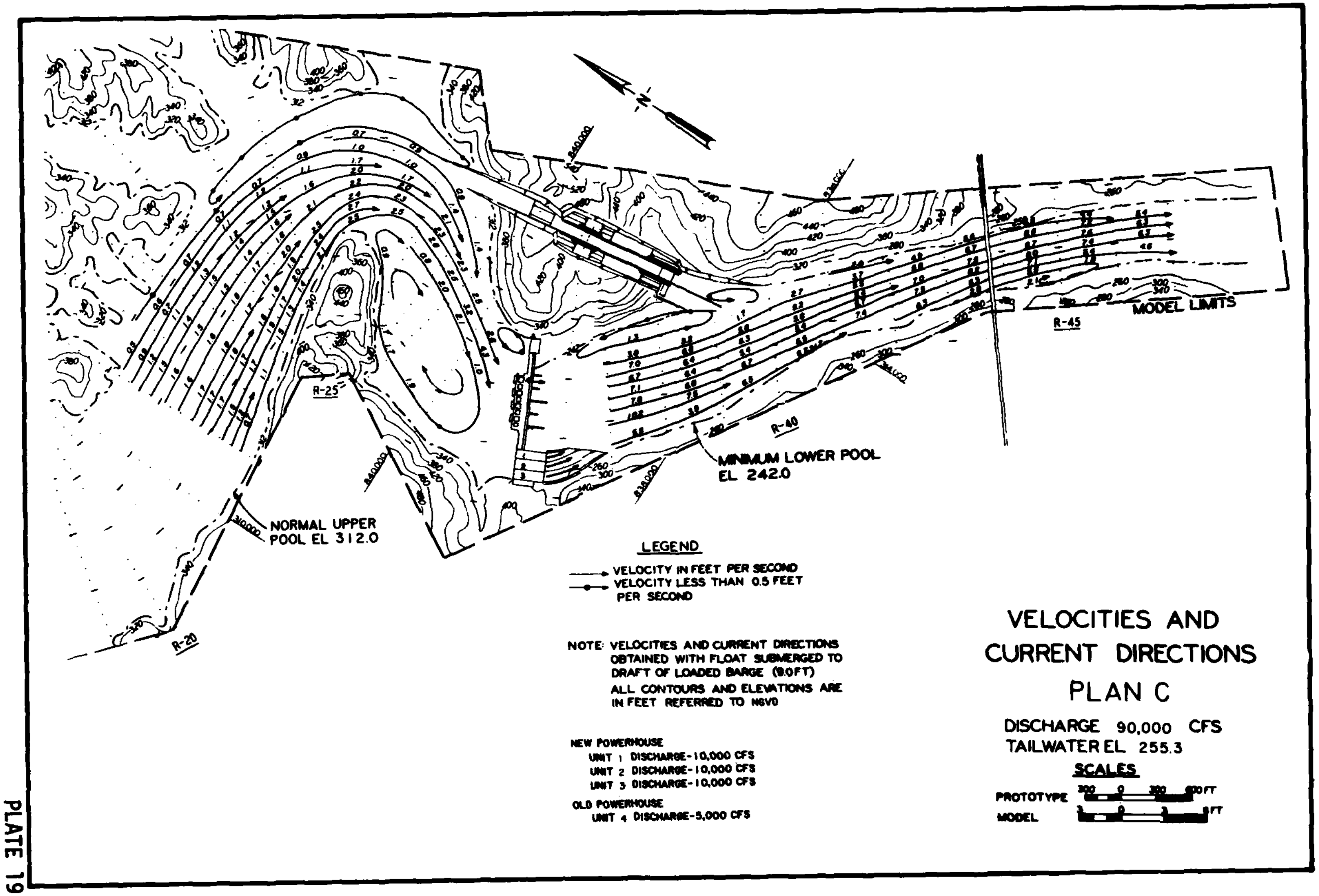
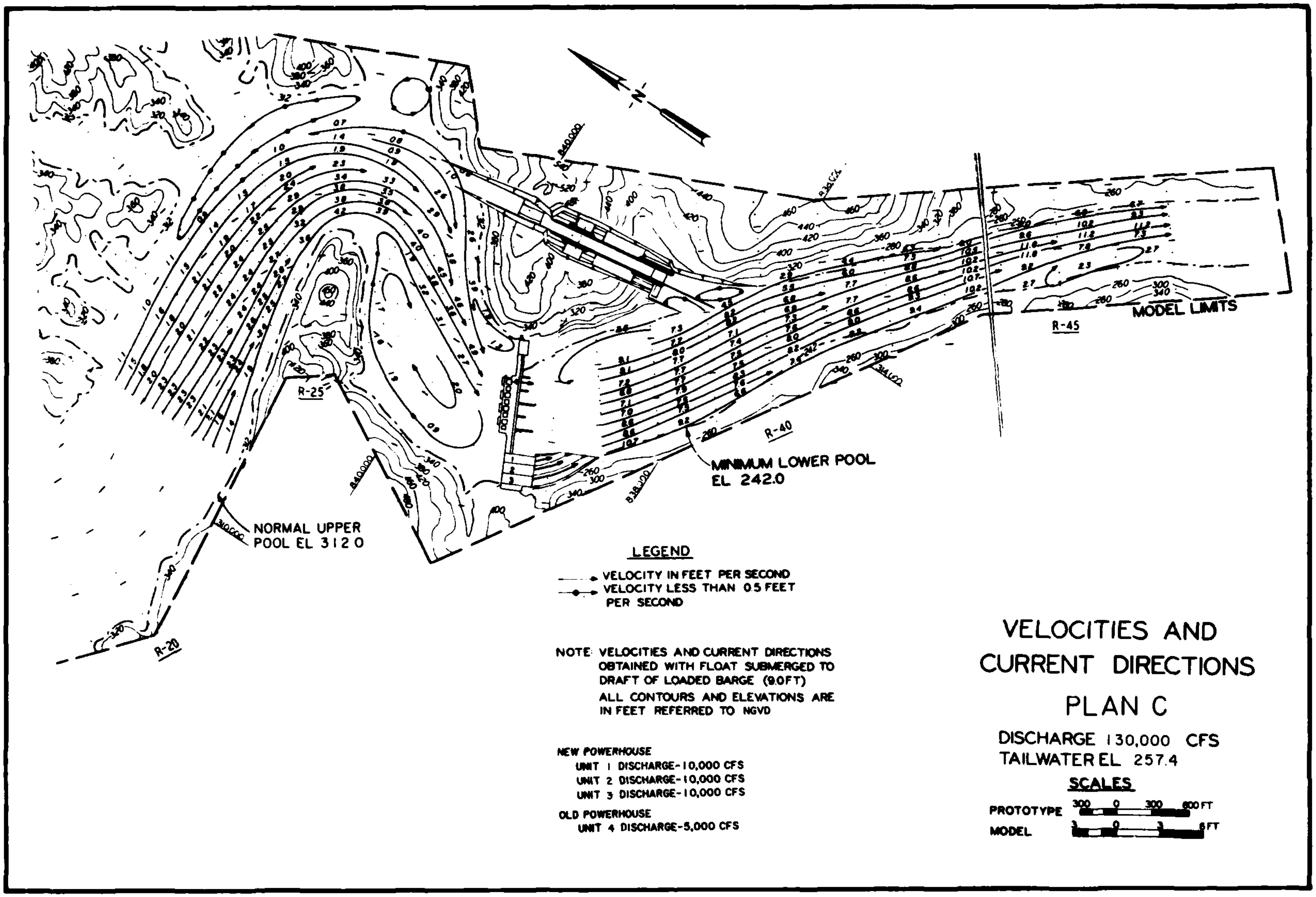
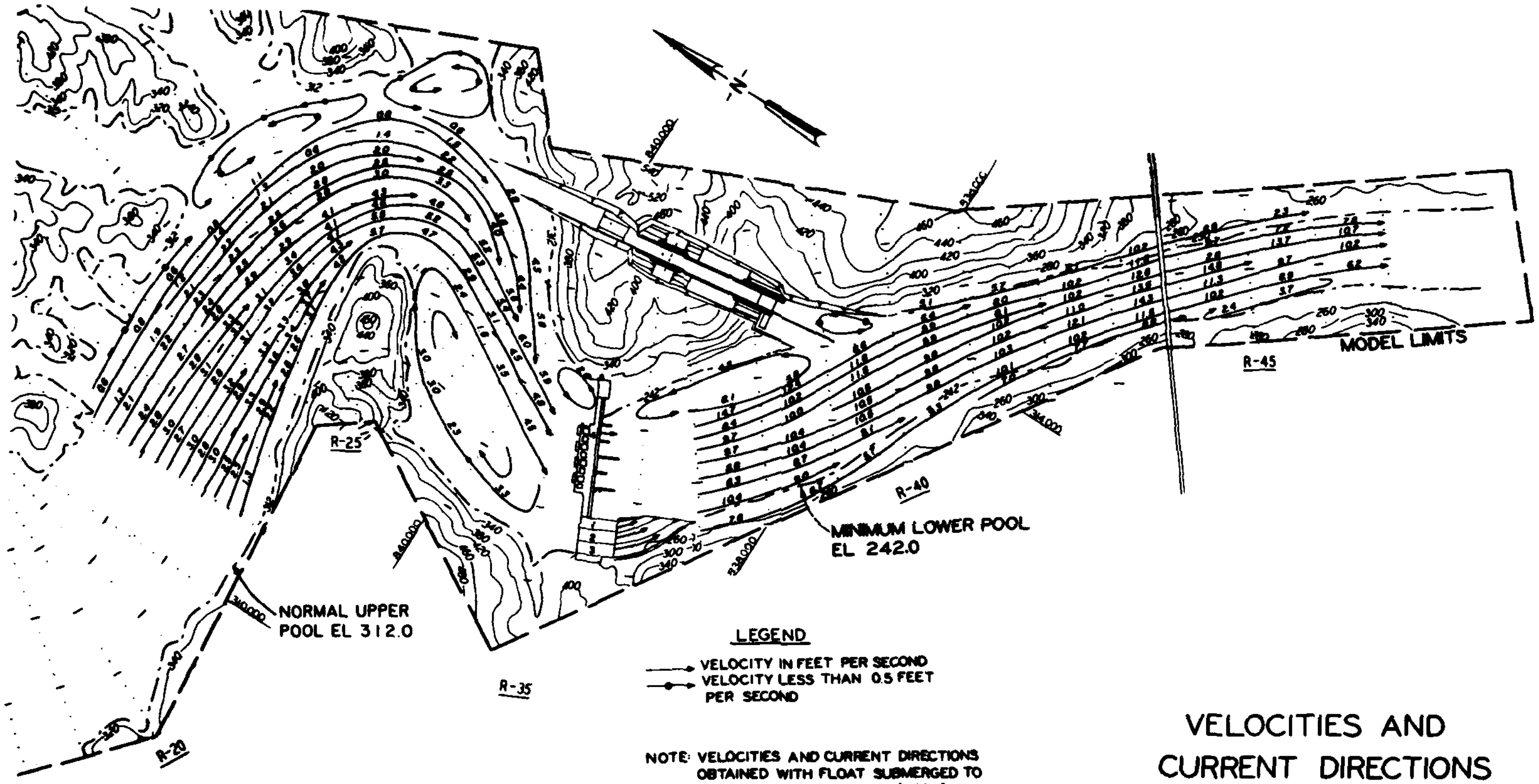

N
MODEL LIMITS
R-20
R-25
R-40
R-45
NORMAL UPPER POOL EL 312.0
MINIMUM LOWER POOL EL 242.0
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT 1 DISCHARGE-10,000 CFS
UNIT 2 DISCHARGE-10,000 CFS
UNIT 3 DISCHARGE-10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE-5,000 CFS
VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE 90,000 CFS
TAILWATER EL 255.3
SCALES
PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT

PLATE 19



VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE 130,000 CFS
TAILWATER EL 257.4
SCALES
PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT
LEGEND
VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD
NEW POWERHOUSE
UNIT 1 DISCHARGE-10,000 CFS
UNIT 2 DISCHARGE-10,000 CFS
UNIT 3 DISCHARGE-10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE-5,000 CFS
NORMAL UPPER POOL EL 312.0
MINIMUM LOWER POOL EL 242.0
MODEL LIMITS
R-20
R-25
R-40
R-45
N

PLATE 20



LEGEND

→ VELOCITY IN FEET PER SECOND
•→ VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

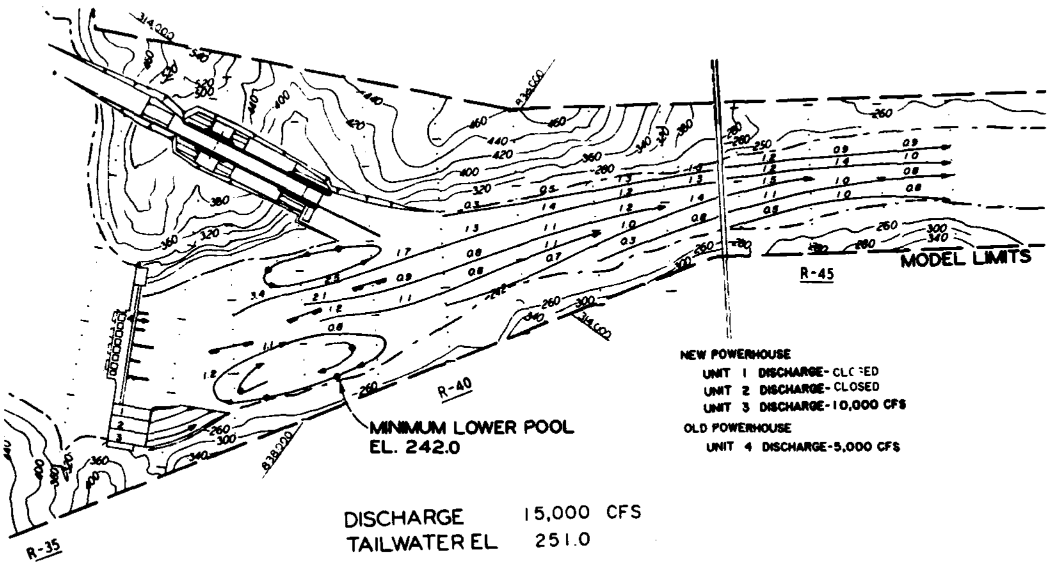
NEW POWERHOUSE
UNIT 1 DISCHARGE-10,000 CFS
UNIT 2 DISCHARGE-10,000 CFS
UNIT 3 DISCHARGE-10,000 CFS
OLD POWERHOUSE
UNIT 4 DISCHARGE-5,000 CFS

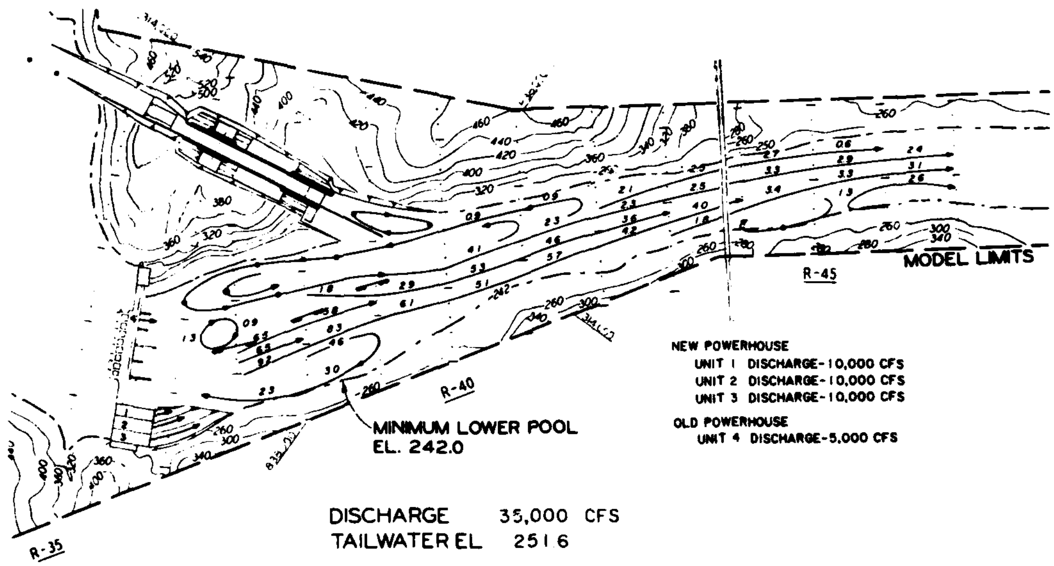
VELOCITIES AND CURRENT DIRECTIONS
PLAN C

DISCHARGE 175,000 CFS
TAILWATER EL 260.0

SCALES

PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT





LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9 FT). ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

VELOCITIES AND CURRENT DIRECTIONS

PLAN C-1

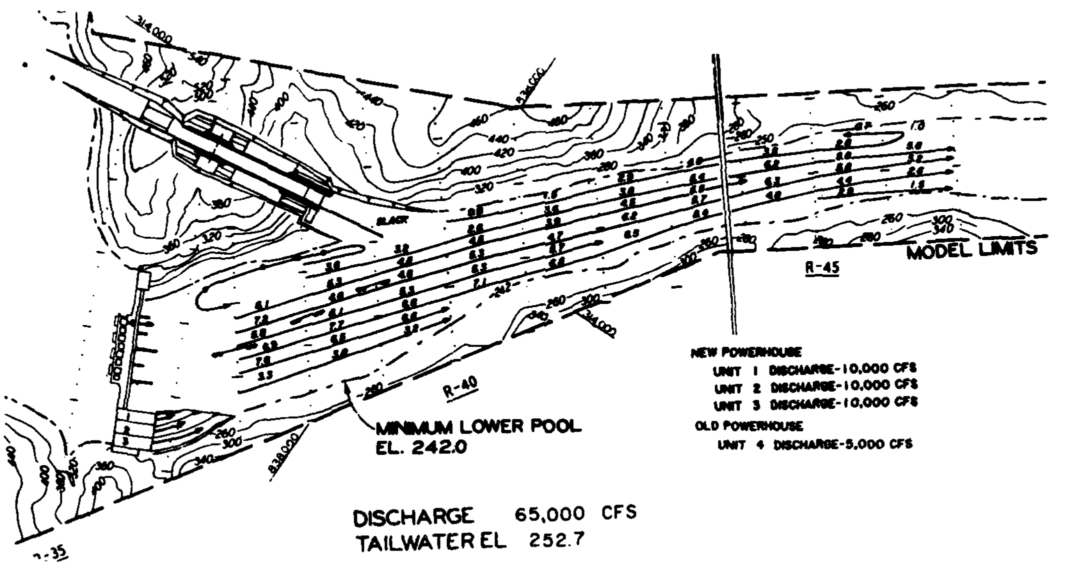
DISCHARGES 15,000 AND 35,000 CFS

SCALES

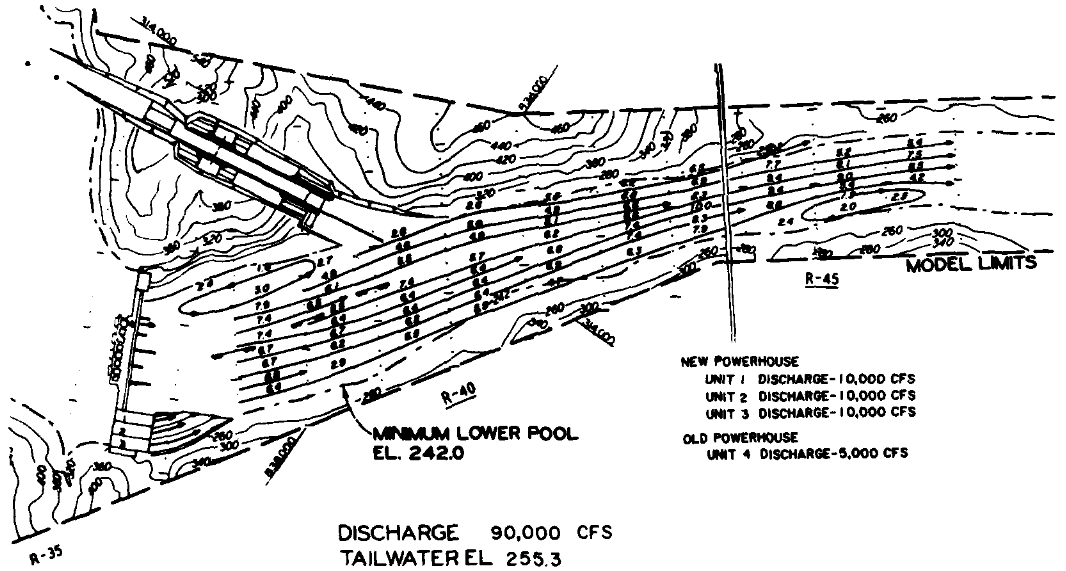
PROTOTYPE 300 0 300 600 FT

MODEL 3 0 3 6 FT

PLATE 22



DISCHARGE 65,000 CFS
TAILWATER EL 252.7



DISCHARGE 90,000 CFS
TAILWATER EL 255.3

LEGEND

VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND

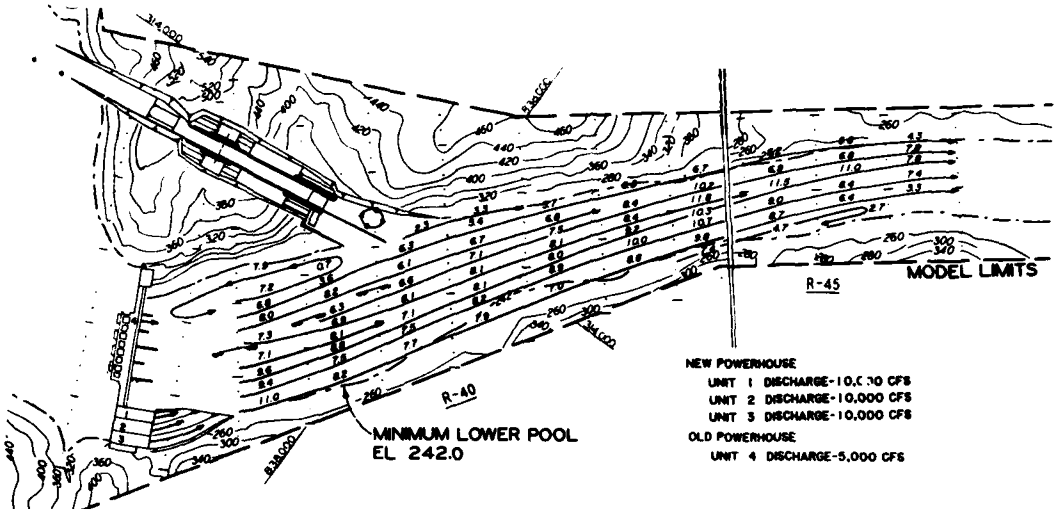
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9 OFT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

VELOCITIES AND CURRENT DIRECTIONS
PLAN C-1

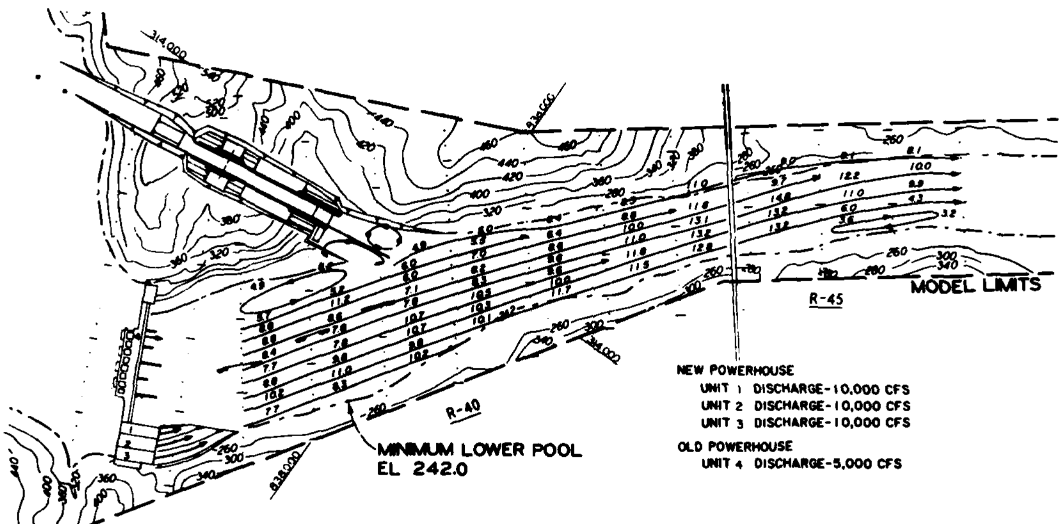
DISCHARGES 65,000 AND 90,000 CFS

SCALES

PROTOTYPE 300 0 300 600 FT
MODEL 3 0 3 6 FT



DISCHARGE 130,000 CFS
TAILWATER EL 257.4



DISCHARGE 175,000 CFS
TAILWATER EL 260.0

LEGEND

- VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

VELOCITIES AND CURRENT DIRECTIONS

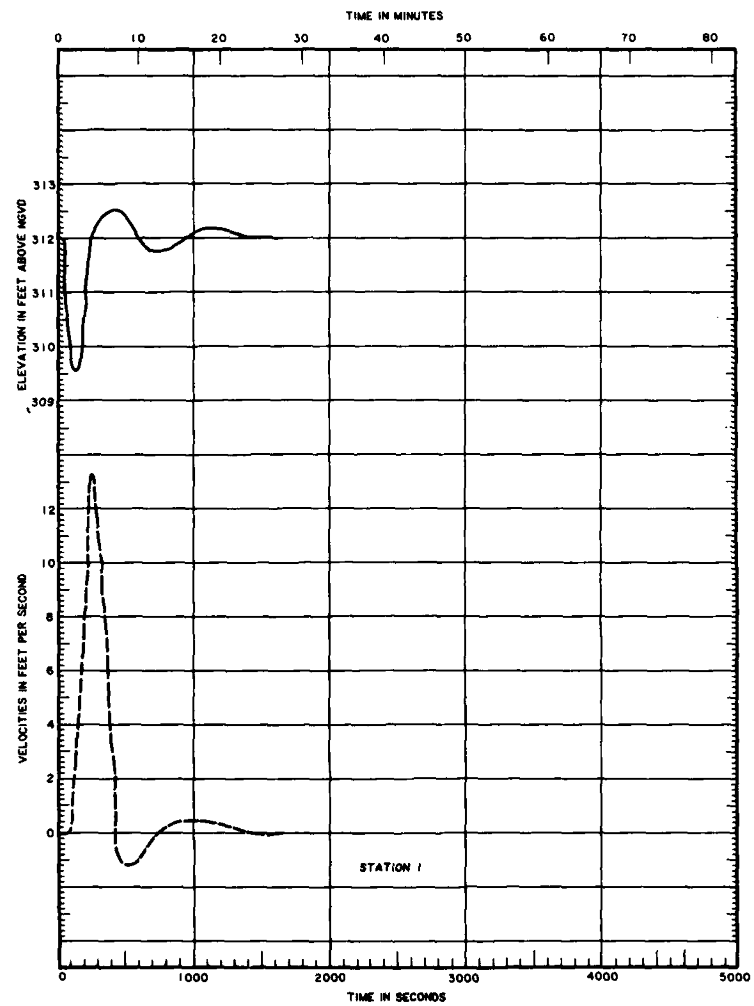
PLAN C-1

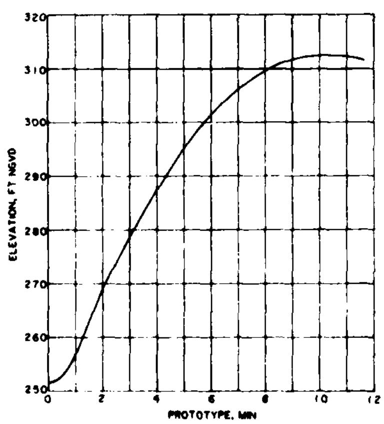
DISCHARGES 130,000 AND 175,000 CFS

SCALES

PROTOTYPE 300 0 300 600 FT

MODEL 3 0 3 6 FT





LOCK FILLING CURVE

LEGEND

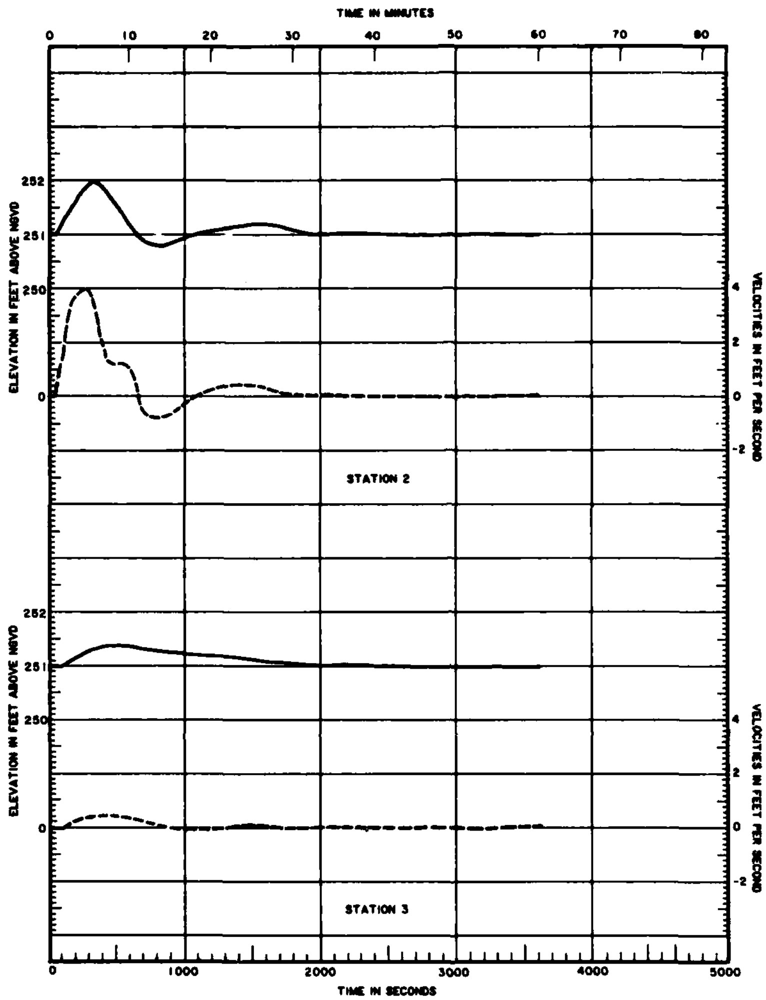
——— ELEVATION IN FT ABOVE NGVD

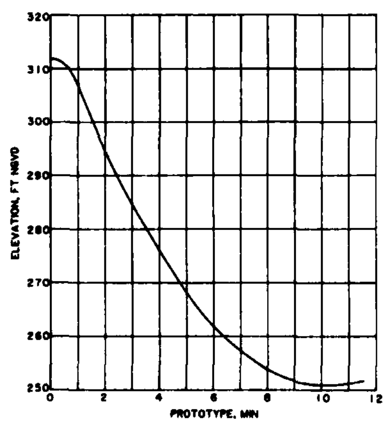
- - - VELOCITIES IN FT PER SECOND

SURGES

LOCK FILLING

RIVER DISCHARGE = 0 CFS





LOCK EMPTYING CURVE

LEGEND

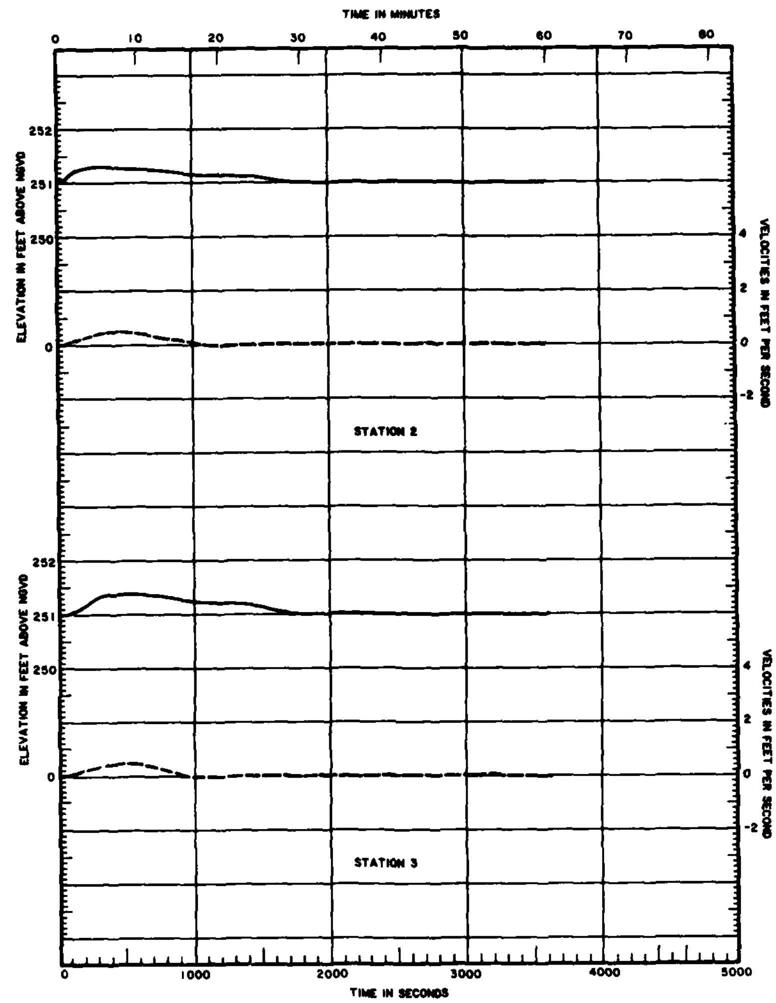
——→ ELEVATION IN FT ABOVE NGVD

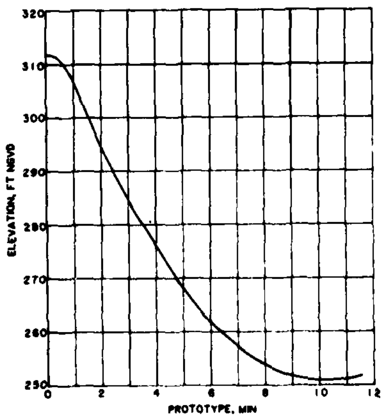
- - - → VELOCITIES IN FT PER SECOND

SURGES

LOCK EMPTYING INTO LOWER LOCK APPROACH

RIVER DISCHARGE = 0 CFS





LOCK EMPTYING CURVE

LEGEND

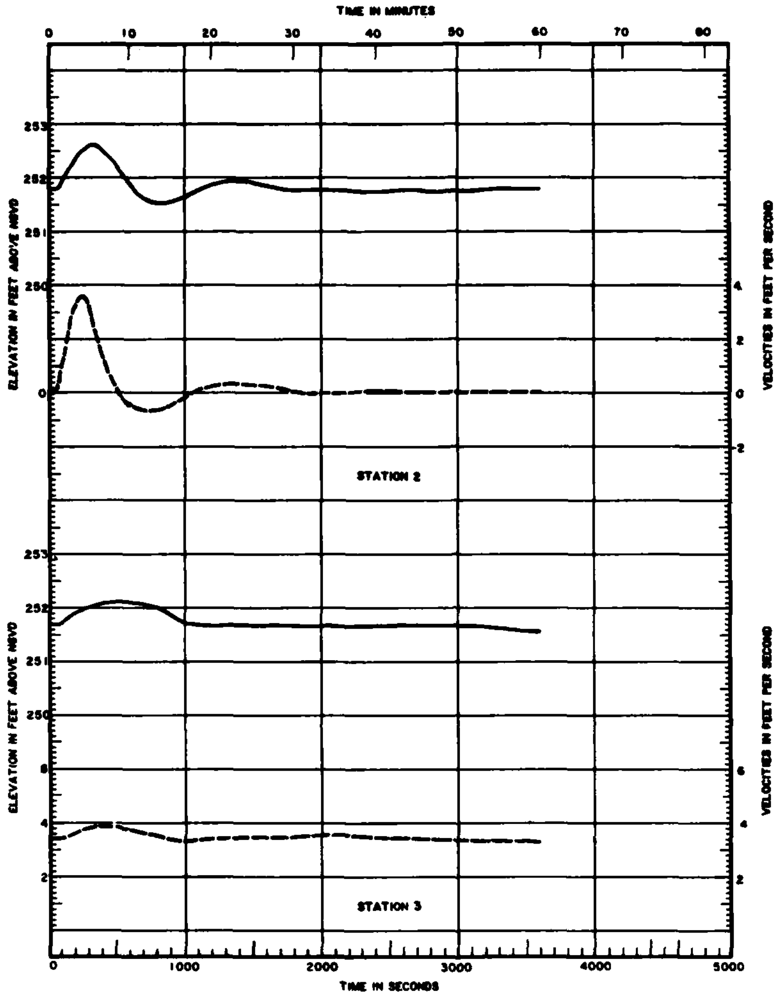
——→ ELEVATION IN FT ABOVE NGVD

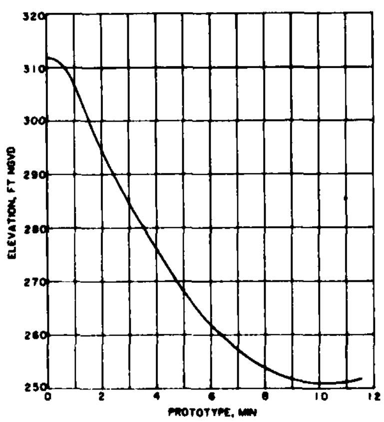
- - -→ VELOCITIES IN FT PER SECOND

SURGES

LOCK EMPTYING INTO RIVER

RIVER DISCHARGE = 0 CFS





LOCK EMPTYING CURVE

LEGEND

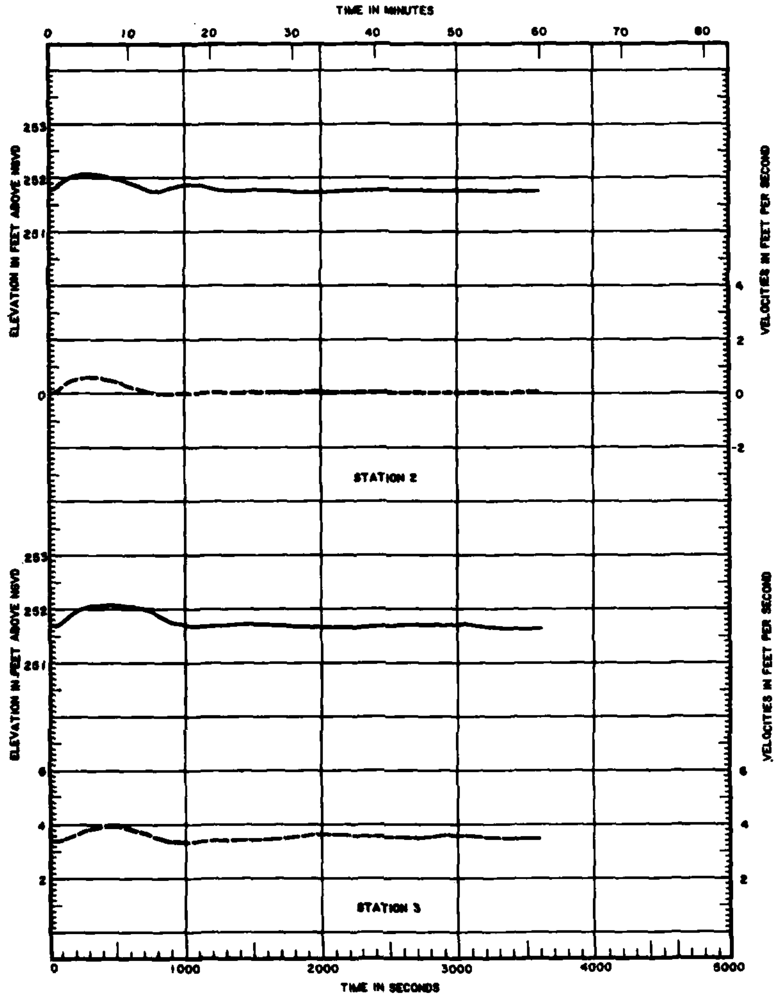
——→ ELEVATION IN FT ABOVE NGVD

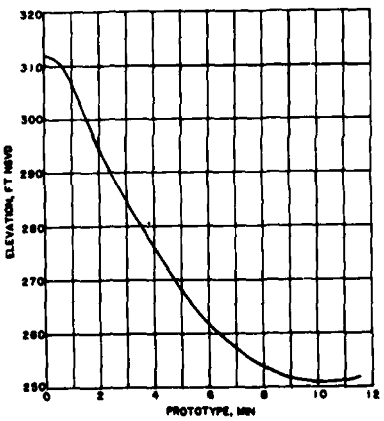
- - - → VELOCITIES IN FT PER SECOND

SURGES

LOCK EMPTYING INTO LOWER LOCK APPROACH

RIVER DISCHARGE = 35,000 CFS





LOCK EMPTYING CURVE

LEGEND

ELEVATION IN FT ABOVE NGVD

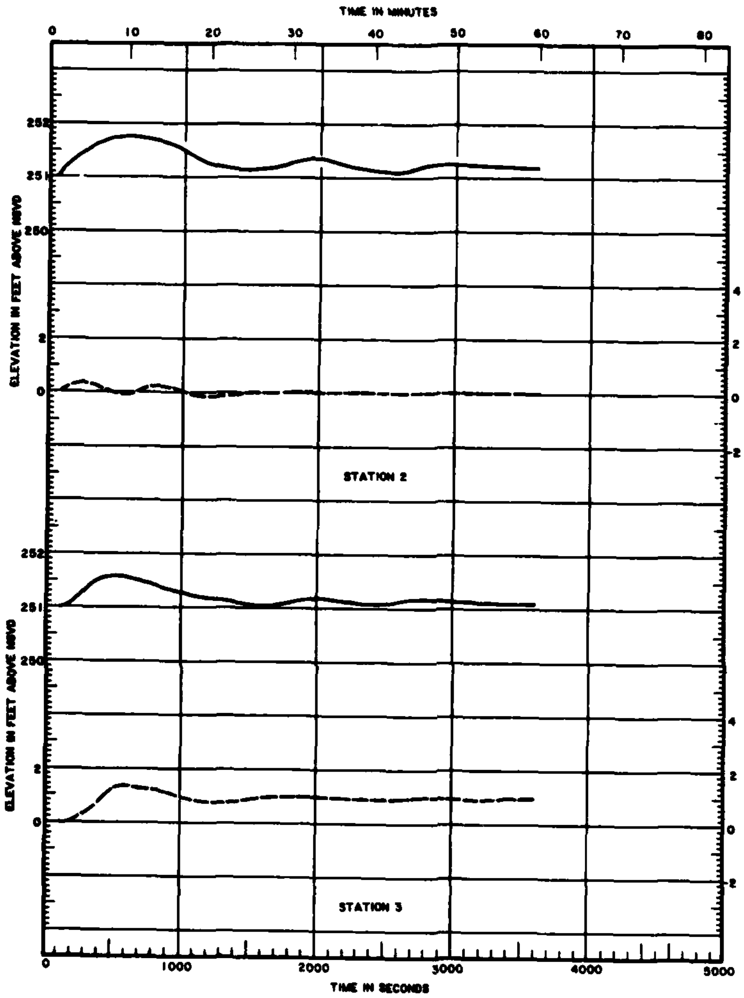
VELOCITIES IN FT PER SECOND

SURGES

LOCK EMPTYING INTO RIVER

RIVER DISCHARGE = 35,000 CFS

PLATE 29



LEGEND

ELEVATION IN FT ABOVE NGVD

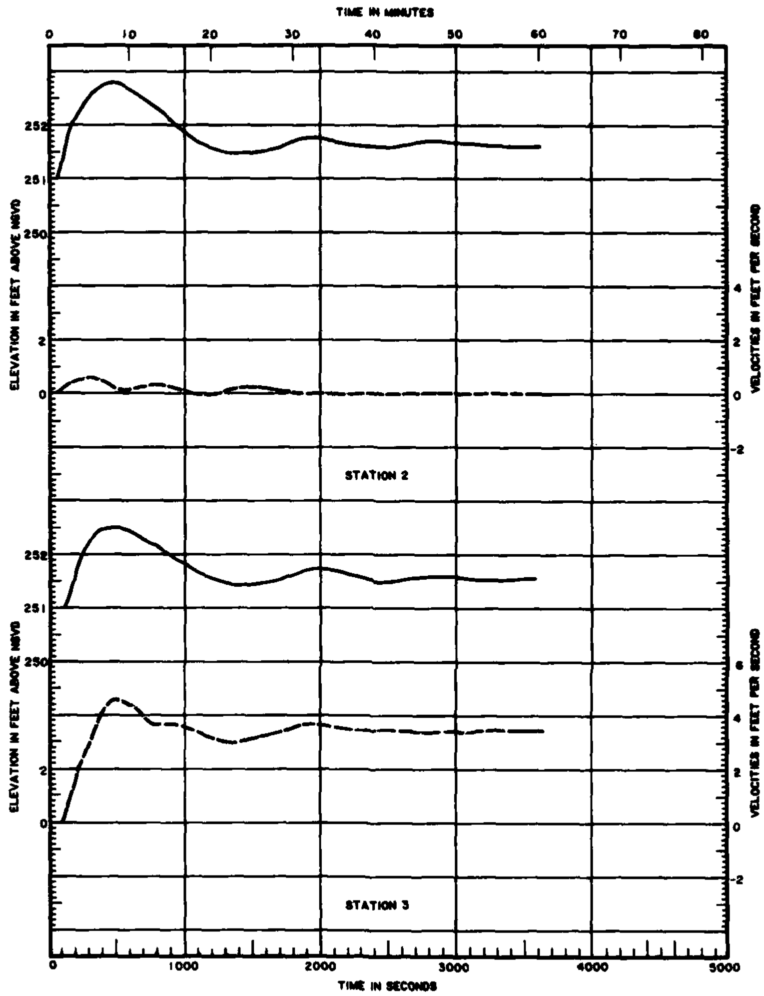
VELOCITIES IN FT PER SECOND

SURGES

ONE POWERHOUSE UNIT LOADED

DISCHARGE = 10,000 CFS

INITIAL TAILWATER EL = 251.0



LEGEND

ELEVATION IN FT ABOVE NGVD
VELOCITIES IN FT PER SECOND

SURGES

FOUR POWERHOUSE UNITS LOADED
DISCHARGE = 35,000 CFS
INITIAL TAILWATER EL = 251.0

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